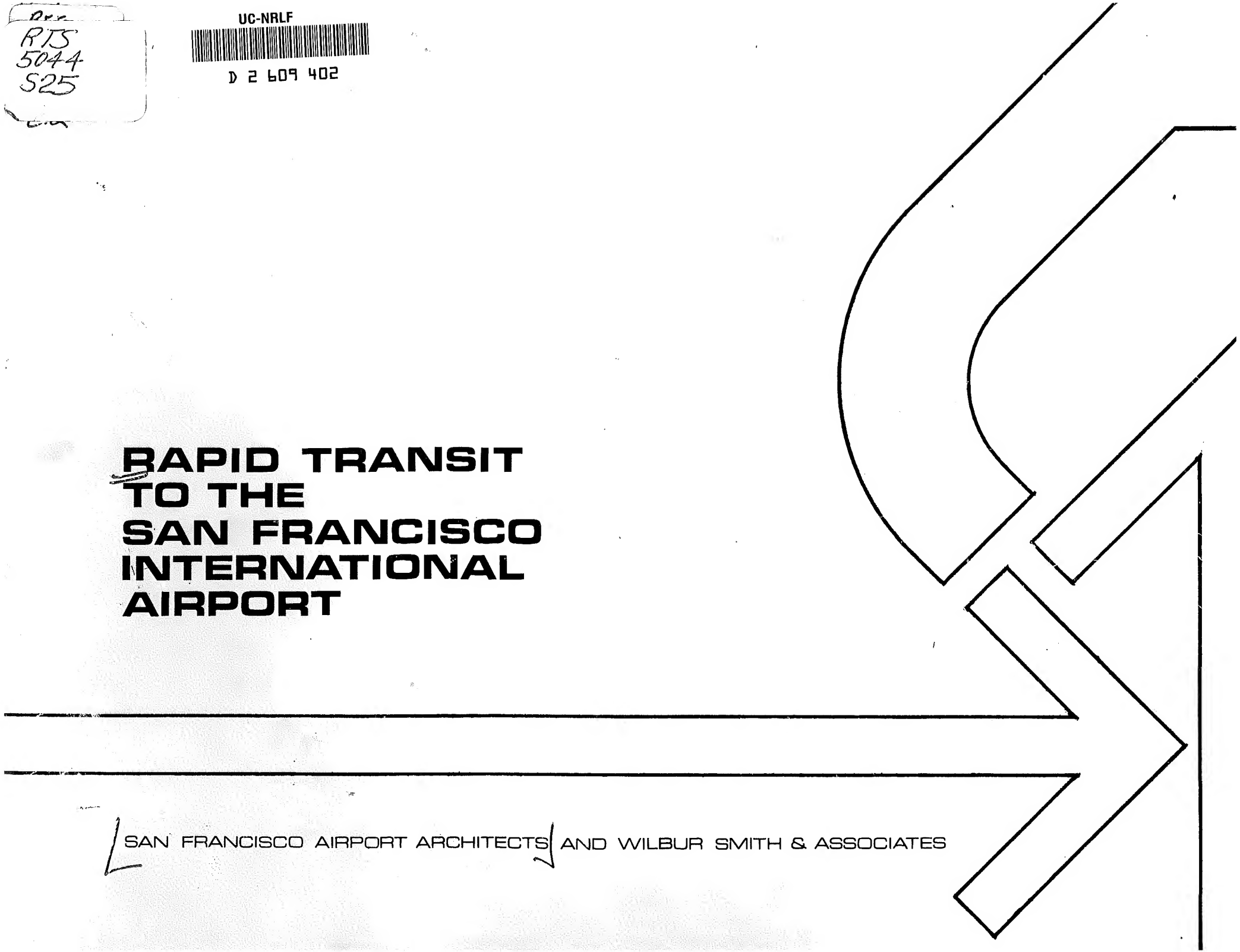
RAPID TRANSIT TO THE SAN FRANCISCO INTERNATIONAL AIRPORT



SAN FRANCISCO AIRPORT ARCHITECTS AND WILBUR SMITH & ASSOCIATES

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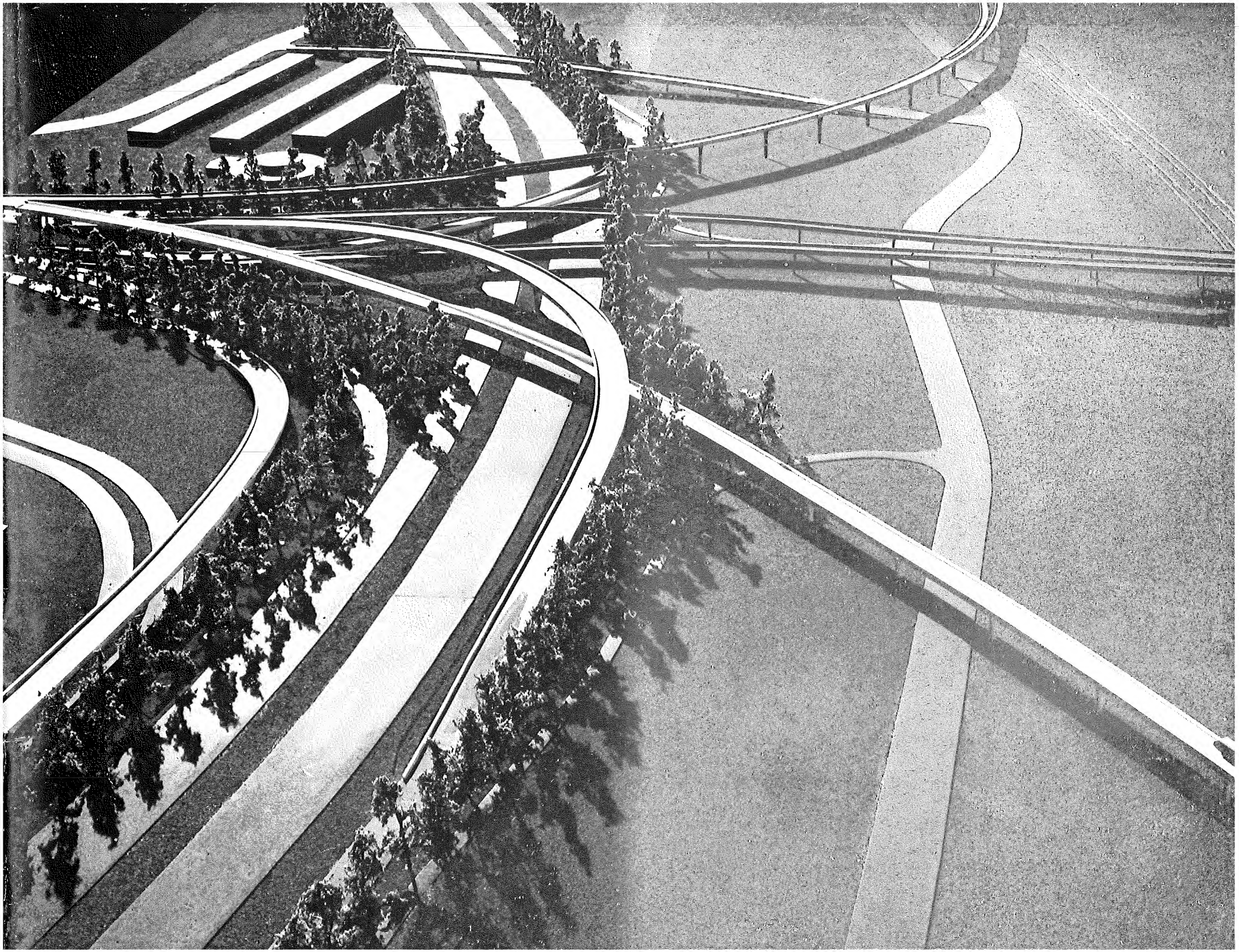

RAPID TRANSIT TO THE SAN FRANCISCO INTERNATIONAL AIRPORT

Prepared for the

PUBLIC UTILITIES COMMISSION
CITY AND COUNTY OF
SAN FRANCISCO

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REPORT OBJECTIVES

The continuing rapid growth of the San Francisco International Airport shows that ground access improvements are a major need. It is clear that rapid transit service is needed if the airport is to reach its optimum regional use as an air-ground transportation transfer point without falling to vehicular access restrictions.

Numerous plans have been suggested for providing rapid transit service between downtown San Francisco and the airport. One suggestion has been direct monorail service. Another suggestion has been the extension of the Bay Area Rapid Transit system now nearing completion. This report is an initial effort to determine the feasibility of extending the BART system into the airport complex.

The study included the determination of alternative alignments for the rapid transit facility, the integration of alternative rapid transit stations with the airport's internal circulation system and the implications of the alignments upon the freeway interchange designs.

Design requirements of BART were analyzed to determine space requirements in the airport terminal area.

Finally, a preliminary analysis was made as to the impact that rapid transit service would have in meeting airport ground access needs. Related to this is the financial feasibility of the project.

ABSTRACT

REPORT FINDINGS

Extending BART to the airport can be accomplished in any one of several feasible ways with widely varying construction cost implications.

An extension of BART from Daly City to a stub-end station at the upper level of the Central Space is estimated to cost approximately $90 million based on previous study efforts.

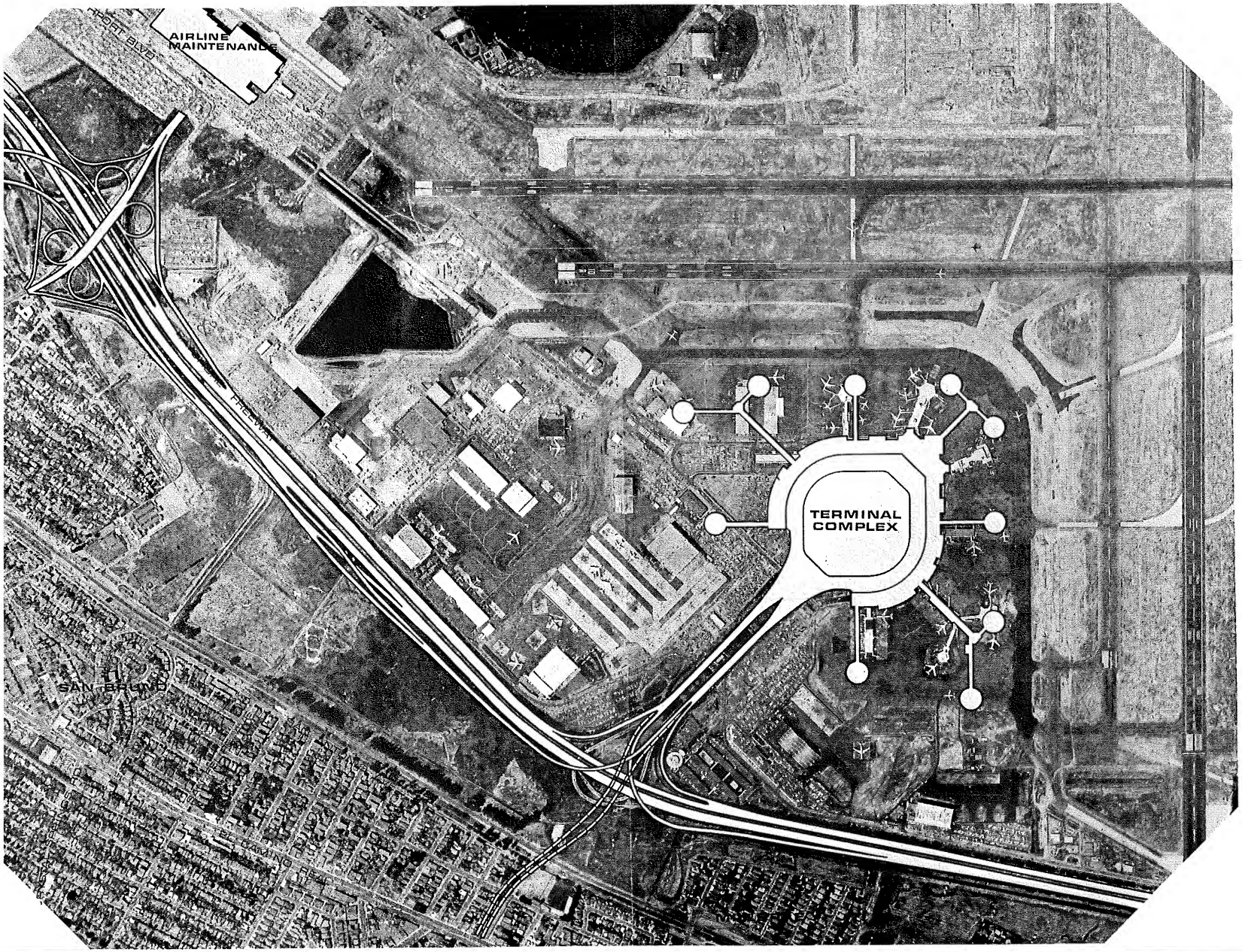
The BART extension could reduce peak-hour traffic on the airport entrance roadway by 15 to 20 percent and daily automobile storage requirements in the airport terminal area by about 3,000 stalls.

BART travel time between downtown San Francisco and the airport would range between 20 and 24 minutes depending on the number of intermediate stops. It would appear economical to have train service at 6-minute intervals for about a 14-hour base period every day of the week. Less frequent service might be operated an additional 6 hours each day.

A BART subway through the airport with a subway station at the parking garage has not been investigated previously because of the major construction problems anticipated. A subway could increase the cost of the project by $30 to $.50 million, if the costs follow BART's more expensive subway construction cost experience. Extending BART south from the airport would add another $20 to $30 million.

BART could carry up to 15% of the air passengers using the airport each year.

It is estimated that the airport rapid transit traffic could add about $5 of revenue to the regional system for each $1 of added operating expense to meet the service requirements. A modest surcharge of 25 cents together with the regular BART fare could produce a revenue surplus of about $5 million per year that could be applied to funding capital costs of the rapid transit extension.



SITE PLAN

IMPROVEMENTS AT SAN FRANCISCO INTERNATIONAL AIRPORT

1

PROJECT SETTING

The San Francisco International Airport is the fourth busiest commercial air passenger terminal in the world and is second only to downtown San Francisco as the Bay Region's largest vehicular traffic generator.

Though located in San Mateo County, the airport is owned by the City and County of San Francisco and operated by the San Francisco Public Utilities Commission. It is bounded by the Bayshore Freeway and the San Francisco Bay, and is eight miles south of the Daly City terminus of the Bay Area Rapid Transit system.

A major effort is being made by several agencies to provide for the airport's future growth. Fig. 1 on the opposite page identifies these improvements which are described in the following section.

Improvement Plans at SFIA

Extensive programs are underway to meet the expanding air travel needs of the Bay Area.

Plans for increasing the capacities of the freeway and airport entrance roadway include:

- widening the main entrance roadway into the airport terminal area to five lanes in each direction;
- re-designing the entrance roadway interchange with the Bayshore Freeway;
- widening the Bayshore Freeway and providing for exclusive ramps between the entrance roadway and the new freeway I-380 about two miles north.

The airport terminal complex is undergoing major expansion to meet the anticipated air passenger demands of the 1970's, this involves the following:

- expansion of the parking garage within the terminal ring and addition of a fifth level of parking;
- design studies for a new control tower, airport offices, and a Central Space which will act as a hub for circulation throughout the airport complex.
- major additions to the terminal space, remodeling of existing terminal structures, construction of new passenger holding areas, and an increase in the number of aircraft gate positions.
- preliminary review of developments in Advanced Baggage Systems (ABS) and People Mover Systems (PMS) to allow their installation as soon as feasible.

Future demand for air travel will require both automated systems. The PMS will link the parking garage, passenger terminals, and aircraft gate positions, allowing the passenger easy and rapid travel to any point in the complex, and the ABS will insure that his bag is not far behind.

There are plans for the expansion of the airlines' maintenance facilities, about a mile north of the airport terminal area. These facilities are the other major employment area at the airport.

Finally, a master land use plan is being developed for the airport lands opposite the airport on the west side of the Bayshore Freeway. The old Market Street Railway right-of-way bounds these lands on the west.

POTENTIAL RAPID TRANSIT DEMAND AT SFIA

A general analysis was made of the geographic distribution of employee and air passenger ground travel from previous origin and destination studies.[1] A comparison of travel costs including the value of time by class of traveler, e.g., employee, air passenger, was made for the principle modes now being used and for rapid transit to obtain a general estimate of the number of persons that might be diverted to rapid transit.

The scope of this study did not permit in-depth analysis of the modal choice effects of extending regional rapid transit to SFIA. The diversion procedure did not define differences in transit usage for the various possible transit alignments. However, the more directly rapid transit service is linked to the center of activity at the airport, the less the risk that patronage estimates will not be realized.

At the present time, about 49 percent of the airport employees come from the Bay Area territory that would be generally served by the new regional rapid transit system including the

[1] Traffic Study San Francisco International Airport, Wilbur Smith and Associates December, 1967.

possible extension. The comparable figure for air passenger ground travel origins is 59 percent.

The regional rapid transit system would have very good linkage between downtown San Francisco and SFIA, which accounts for 20 to 30 percent of the air passenger trips, depending on the season of the year, but only about 3 percent of the employee trips.

The overall result of the diversion procedure was to estimate that about 13 percent of the airport employees and 28 percent of the air passenger and related airport users in the area served would take rapid transit to and from their airport destination.

It is estimated that about 1,000 employees would use rapid transit to reach the maintenance facilities, which would increase total rapid transit usage to the airport by about 10 percent. The estimated effect of the increased transit usage on revenues would approach $400,000 annually. It has not been estimated how many would use a shuttle connection to the maintenance area if there were not a mainline station.

It is assumed in making each estimate that the trips reported from the airport in the 1967 origin and destination survey would double by the time the rapid transit service were offered from the north. The revenue potential of the station at the maintenance facilities should increase considerably, if rapid transit service were later offered from the south where about half of the employees reside.

Rapid Transit into the Airport Terminal Area

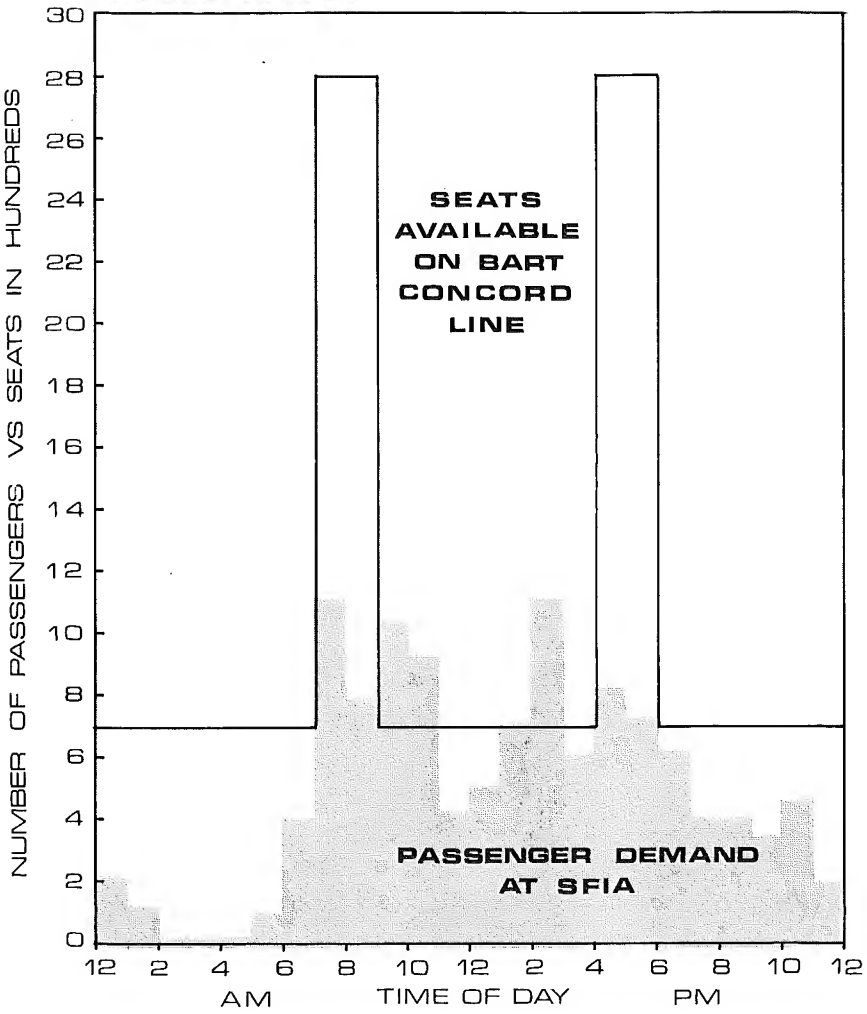
An analysis was made of the time distribution for rapid transit trips to and from the airport terminal area. A graph showing the estimated hourly distribution of these trips is shown in Figure 2 on the next page. The estimated transit capacity requirements during commute peaks are less than half the seat capacity offered by the 4-car trains on the Concord line. Passengers to the airport would probably have little difficulty in finding seats, depending on demand and service to intermediate stations. Obviously, there would be no problem for trips from the airport, if BART terminates there.

The demand for rapid transit at the airport shows no significant peaks, unlike normal commuter transit demand.

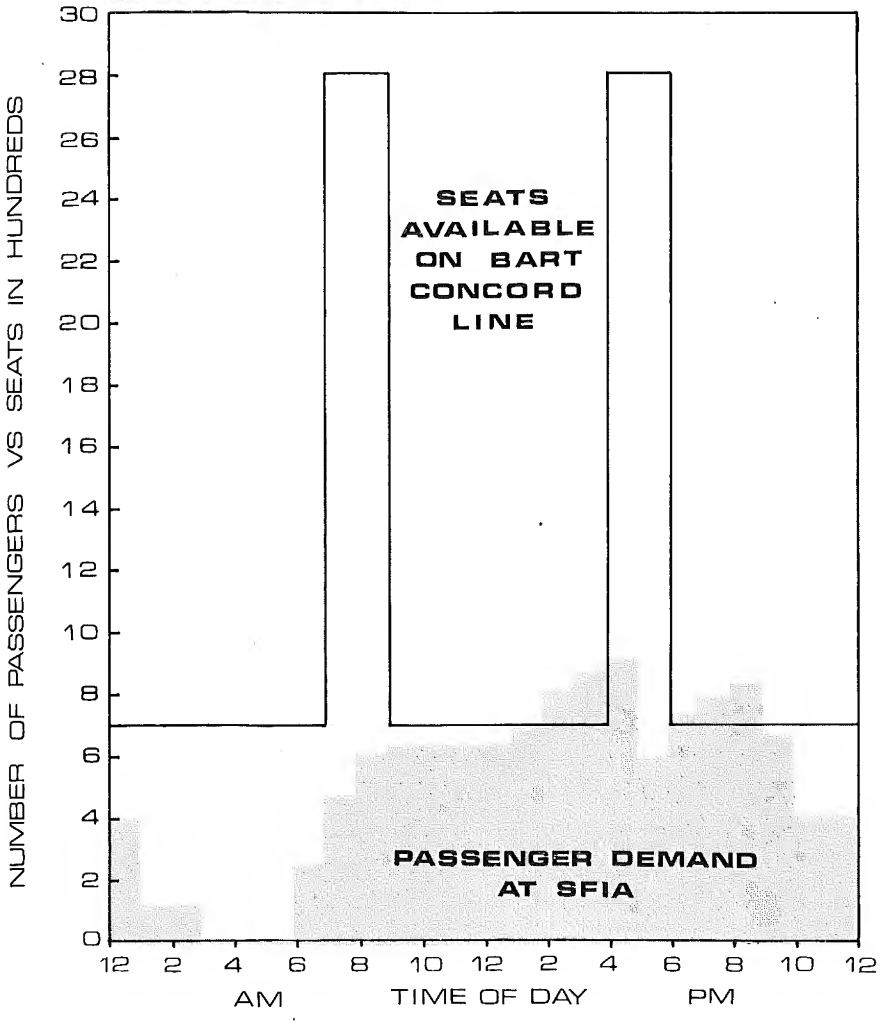
About half of the airport transit users are estimated to be air passengers. Using the diversion procedure, this is nearly 15 percent of the annual number of air passengers served by the Airport.

Approximately 20 percent of the rapid transit users at the airport are estimated to be airport employees. The remaining percent of transit users have airport-related business or serve-passenger functions.

INBOUND



OUTBOUND



NOTE: ESTIMATE OF TRANSIT DEMAND IS BASED ON A 24 MILLION AIR PASSENGER YEAR AT SFIA.

ESTIMATED AVERAGE DAILY TRANSIT DEMAND AT SFIA 2

On an average day, when the airport is serving 24 million air passengers annually, it is estimated there will be a peak-hour demand at the airport late in the morning of about 1,000 inbound transit passengers, slightly less outbound. The peak hour demand would increase to about 1,500 transit passengers, if the airport served 30 million passengers. Assuming BART offers 12-minute off-peak service with two-car trains on the three East Bay lines, traffic at the airport would probably justify bringing in two of the three lines in the off-peak period for six-minute base service. Less frequent service might be provided later in the evening when demand is estimated to fall off (See Figure 2).

With the airport handling 24 million passengers per year, it is estimated that about 25,000 people, will use rapid transit to and from the airport on an average day for a total of approximately 8 million rapid transit users annually. The transit estimate is approximately midway between a low estimate of the demand in the West Bay study and a high estimate of the demand for the Aerial Transport System, a private proposal for exclusive direct service to the airport.

Other Means of Serving the Airport by Transit

The transit demand at the airport as estimated above would not tax the capacity of bus service on an hourly basis. Surges over a shorter duration caused by the jumbo jets, each carrying 300 to 500 people might be more conveniently served by trains with upwards of 300 seats than by buses seating 50. However, on an hourly basis, the number of buses needed would not be sufficient to justify construction of an exclusive bus lane or bus roadway for airport traffic only.

A very important advantage of rail rapid transit at the present time is its comparative reliability, vis-a-vis the freeway access which busses must utilize. Because of frequent freeway traffic delays and capacity restrictions in peak hours, bus travel time to the airport is not reliable at certain times of the day. Consequently, it would be important to improve the reliability of bus service using the freeway to the airport.

In addition to the possibility of providing express bus service to serve the rapid transit demand at the airport, there are private proposals for exclusive direct service using a monorail system. However, the rapid transit demand at this traffic generator offers an important revenue source for the ultimate development of a regional rapid transit system on the San Francisco Peninsula.

Public policy will ultimately be required to determine whether the rapid transit demand at the airport should be provided for separately

or combined in the planning of a regional rapid transit system.

Airport Traffic Relief

A consideration of traffic estimates and road improvement plans in the vicinity of the airport was made together with the analysis of transit demand at the airport. A preliminary analysis was made of the projected capacities of the main entrance roadway after it is widened to five lanes in each direction and of the new interchange at the Bayshore Freeway.

The critical section for capacity is the traffic weave just after the interchange ramps merge into the entrance roadway where drivers attempt to reach the proper lane of the entrance roadway for their airport destination.

Future peak period traffic estimates have been made by the California Division of Highways, Wilbur Smith and Associates, and the West Bay Rapid Transit Authority. The latter estimates are the highest for both 1975 and 1990. Using these estimates, the section would have adequate capacity with the present vehicle mix in the average peak-hour through 1975, but would approach severe congestion after 1975, assuming the airport expands toward a 30-million annual air passenger level.

As congestion grows, a relatively larger percentage of this traffic would doubtless ride rapid transit if available.

Unknown in these evaluations, however, is the additional traffic surge within a peak hour that the new jumbo jets may cause. Also unknown is the performance of the garage and curb loading sections in the terminal area. These may back traffic into the critical weaving section. There are and there will continue to be peak days at the airport when this will occur.

It is estimated that the traffic diverted to transit would reduce vehicle volumes on the entrance roadway 15 to 20 percent, which is enough to maintain the traffic flow at the 30-million air passenger level. Some further reduction in vehicle traffic would also occur if the rapid transit service were extended south.

Airport Parking Relief

The effect of rapid transit service on reducing automobile storage requirements was estimated for the airport terminal area. It was not possible to determine whether this would be in excess of what is being supplied under the current garage expansion plans. The current data on parking patterns at the airport have been compiled as incidental parts of studies to analyze ground access to the airport. More specific data on parking duration by trip purpose to the airport would be desirable.

There are three significantly different parking demand categories that will be relieved by the diversion to rapid transit. In the first category is the short-term parker, who is there to pick-up or drop-off an air passenger or to conduct miscellaneous airport business. One parking stall may serve five of these trips during the day. Obviously these people cause most of the work for the cashiers at the exit gates of the garage.

The second category is the employee who needs a parking stall each day.

Third, there is the air passenger who has brought his car and will leave it at the airport while he is away on a trip. These are relatively low in absolute number, but expand the parking requirements at the airport very rapidly.

Previous data on parking at SFIA indicate less than 20 percent of the parkers stay more than 12 hours, but utilize about 75 percent of the parking space in the garage. At Los Angeles International Airport, 7.5 percent of the parkers remain beyond 24 hours and utilize 72 percent of the parking capacity.

Reliable data are not available on the average duration of parking for air passengers at SFIA. However, based on the national average, each air passenger who parks his car at the airport garage increases the parking requirement by 2.5 stalls. Obviously, this group has tremendous leverage on the parking requirements at the airport and should be studied more carefully. In fact, the aggregate parking demand for all the groups should be estimated in order to determine whether rapid transit may be relieving what could be a future critical parking shortage or possibly causing an excess of supply that could affect airport financing.

Based on preliminary estimates of rapid transit patronage and the rough parking turnover experience just stated, rapid transit could reduce the demand for parking in the airport terminal area by about 3,400 stalls on an average day. The reduction in demand could distribute over the three categories as follows:

1,000 short-term stalls
1,500 employee stalls
900 air passenger stalls.

The estimate assumes a 24 million air passenger year.

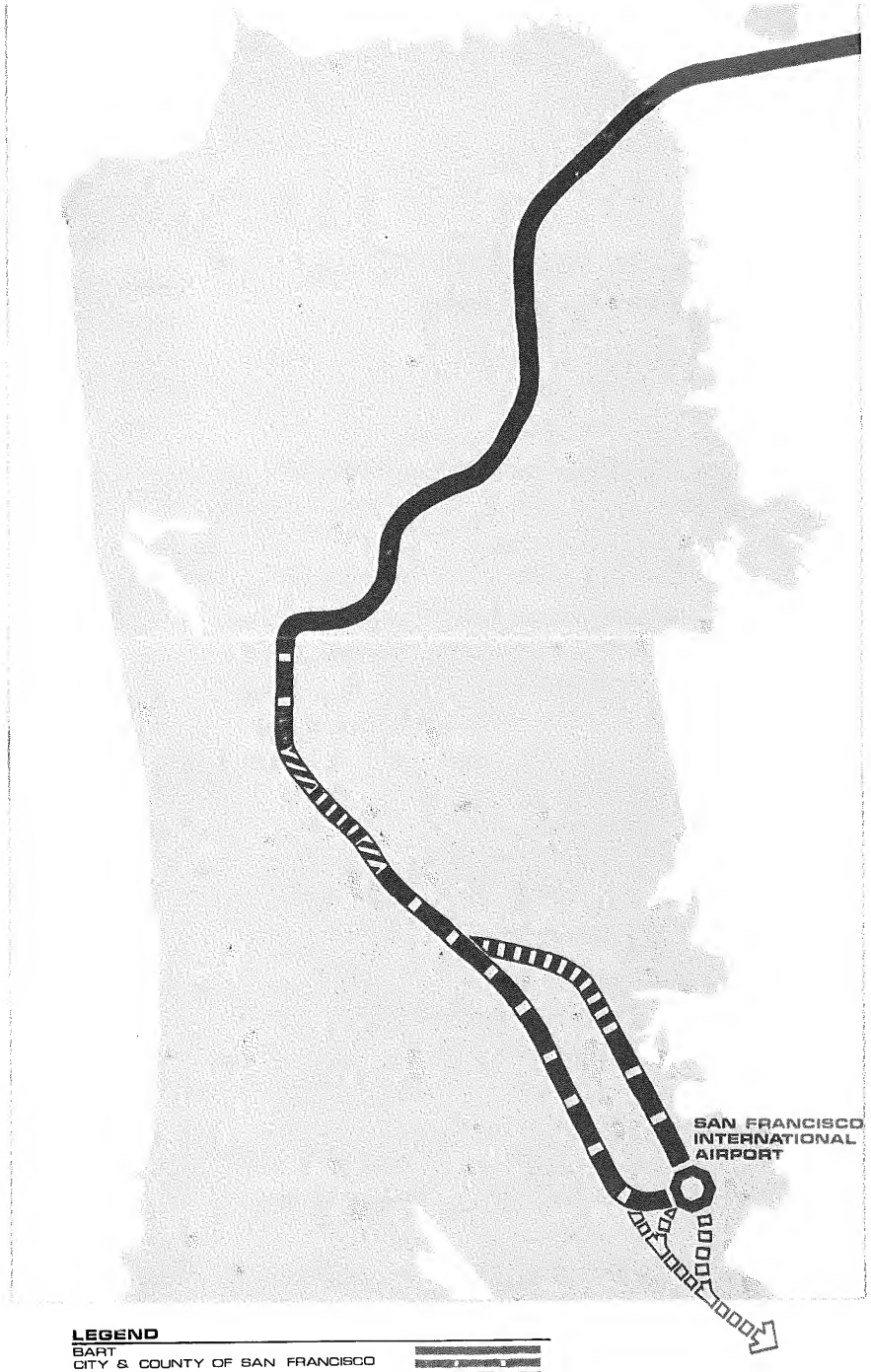
There is the possibility of lower revenue from airport parking, bus, taxi, and car rental concessions as the result of a rapid transit extension. On the other hand, there may be added revenue from other concessions that is brought about by the airport growth made possible by rapid transit. The net financial impact on the airport may be a logical part of a more in-depth study of the financial feasibility of extending BART to the San Francisco International Airport.

BART EXTENSION ALTERNATIVES

In considering the alternate BART extension alignments to SFIA, it was assumed that each would have the Daly City BART station as a starting point. A previous study indicated that a more direct extension of BART down the Bayshore corridor would duplicate several miles of the BART line now being constructed.[2] This was estimated to double the cost of extending rapid transit service to SFIA and would produce only a two to five-minute time saving. This large additional cost for a relatively slight time saving would make an extension of BART from Daly City the most logical routing.

BART is presently planned to terminate at Knowles Avenue in Daly City, aligned with the San Bruno branch line of Southern Pacific Railway Company.

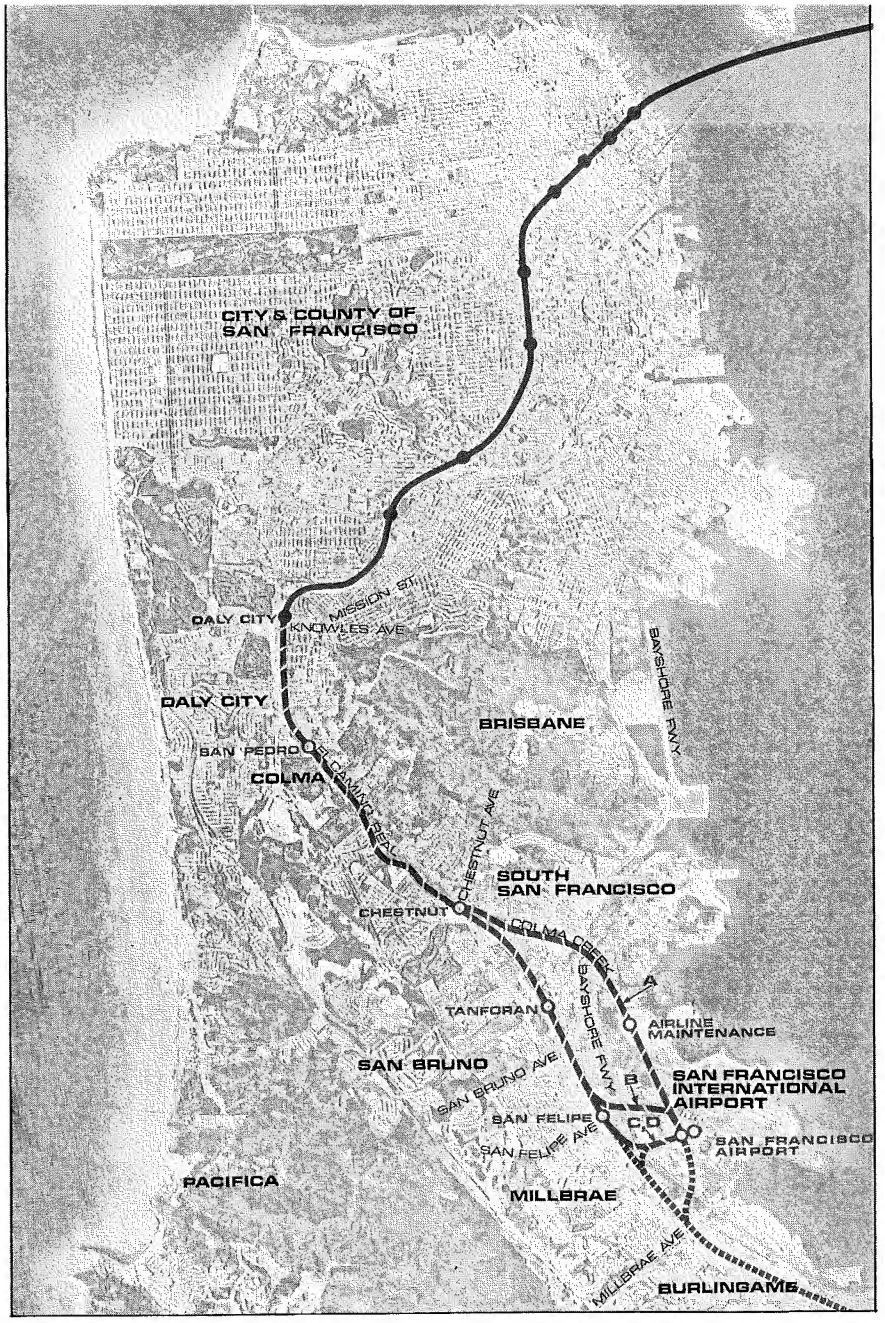
[2] Engineers Working Paper Final Report for West Bay Rapid Transit Authority, George S. Nolte, Consulting Civil Engineers, Inc., DeLeuw Cather & Company, December, 1968, pp. 5-7 to 5-9



LEGEND

- BART
- CITY & COUNTY OF SAN FRANCISCO
- OTHER PUBLIC
- PRIVATE
- FUTURE

POSSIBLE BART EXTENSION RIGHTS-OF-WAY



LEGEND

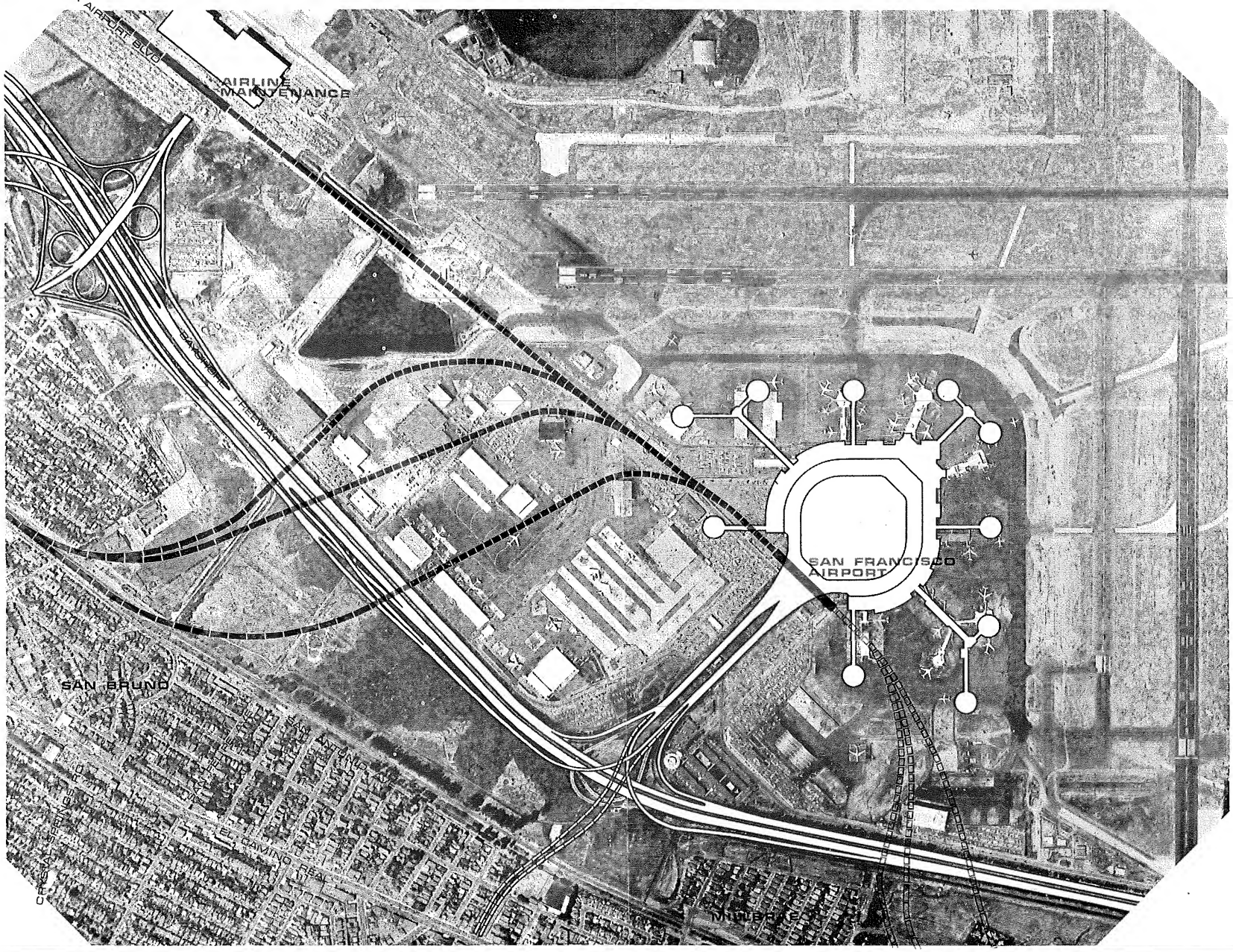
- UNDER CONSTRUCTION
- ALTERNATE ALIGNMENTS FROM DALY CITY TO SFIA
- ALTERNATE FUTURE EXTENSION SOUTH OF SFIA
- BART STATION UNDER CONSTRUCTION
- BART STATION

BART EXTENSION ALTERNATIVES

The BART extension would start at Knowles Avenue as planned in the West Bay Rapid Transit study and use about 7,000 feet of the Southern Pacific branch line right-of-way to the vicinity of A Street in Daly City.

The alignment would then stretch about 1,700 feet across land in private ownership before entering the median of the El Camino Real. It would follow the median to the intersection with Mission Road where the alignment would cross about one-half mile of privately held land to reach the Old Market Street Railway right-of-way now owned by San Francisco. From this point on to the airport, the right-of-way is generally open. It is approximately 60 feet wide except for infringements caused by minor private improvements and local street widening programs. The width required to accommodate BART trunk line facilities is normally 50 feet whether at-grade or on structure. Also, the Southern Pacific branch line is adjacent to the San Francisco right-of-way adding approximately 60 feet to the width of open right-of-way to San Bruno. The unusual opportunity these two adjacent open rights-of-way provide for joint planning of park development in this corridor should be considered early in a project to extend rapid transit. These rights-of-way are illustrated in Figure 3.

There are four basic alternative alignments for bringing BART service to SFIA from Daly City. Each is shown on Figure 4 and each will be des-



N

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LEGEND

- SUBWAY LINE TO SFIA
- AERIAL LINE TO SFIA
- SUBWAY LINE OF POSSIBLE EXTENSION SOUTH OF SFIA
- AERIAL LINE OF POSSIBLE EXTENSION SOUTH OF SFIA
- BART STATION

ALTERNATE BART MAINLINE ALIGNMENTS TO SFIA

cribed in order as they leave the Market Street Railway right-of-way approaching the airport from Daly City. Variations within these basic alternatives are shown in later figures.

Alignment A

Alignment A would leave the Market Street Railway right-of-way at Chestnut St. in South San Francisco and generally follow Colma Creek to the east side of South Airport Boulevard, then continue along the east side of South Airport Boulevard past the airline maintenance facilities. It is assumed that the rapid transit would be on structure to this point with a station to directly serve the maintenance facilities. The line would then change to subway for approximately one mile to reach the airport terminal area. A subway station at the western edge of the parking garage would directly serve the air terminal area. If the line were continued south beyond the airport terminal area, it would be in subway for about another three-quarters of a mile until it crossed the Bayshore Freeway. On the west side of the freeway, the line would rise above grade to cross the Southern Pacific mainline and merge back into the Market Street Railway right-of-way in the vicinity of Millbrae Avenue. This alignment is shown in more detail in Figure 5.

Alignment B

Alignment B would leave the Market Street Railway right-of-way in the southern part of San Bruno about two miles south of Alignment A. It would cross the Southern Pacific on structure, then descend to a subway under the Bayshore Freeway. Several possible alignments for this section are shown in Figure 5. It would require about a mile of subway to reach the underground airport terminal station where it would then follow the first alternative alignment back to the Market Street Railway right-of-way. This alignment involves about the same amount of expensive and difficult subway construction at the airport as Alignment A, but does not offer mainline rapid transit service at the maintenance facilities. These facilities could be served by a bus shuttle from a rapid transit station at Tanforan Street in San Bruno.

Implications of Airport Subway Service

The subway alignments serve the second largest trip generator in the Bay Area more directly than the other alignments. There would be direct rather than shuttle service to the airline maintenance facilities with the first subway alignment, and direct service to the air terminal area for both of the subway alignments. The direct service would be continued even after an extension of

rapid transit further south. For the two remaining alternatives, after a rapid transit extension south, the air terminal area would either have to be served with a branch line and possibly compromise mainline service or be served with a shuttle from a mainline rapid transit station and possibly compromise airport service.

These two subway alignments involve the most complex and expensive engineering problems of the four alternatives suggested. It is beyond the scope of this report to estimate the cost of constructing a relatively shallow subway line across the airport fill lands. Cost ranges are given only to define general cost limits.

The present instrument landing system would probably require relocation under the first alignment. Several taxiways and aprons would be blocked at various times during construction of either subway alignment. The length of time that these were blocked would have to be negotiated with the parties involved and the ultimate cost to meet this time requirement would depend on Yankee ingenuity.

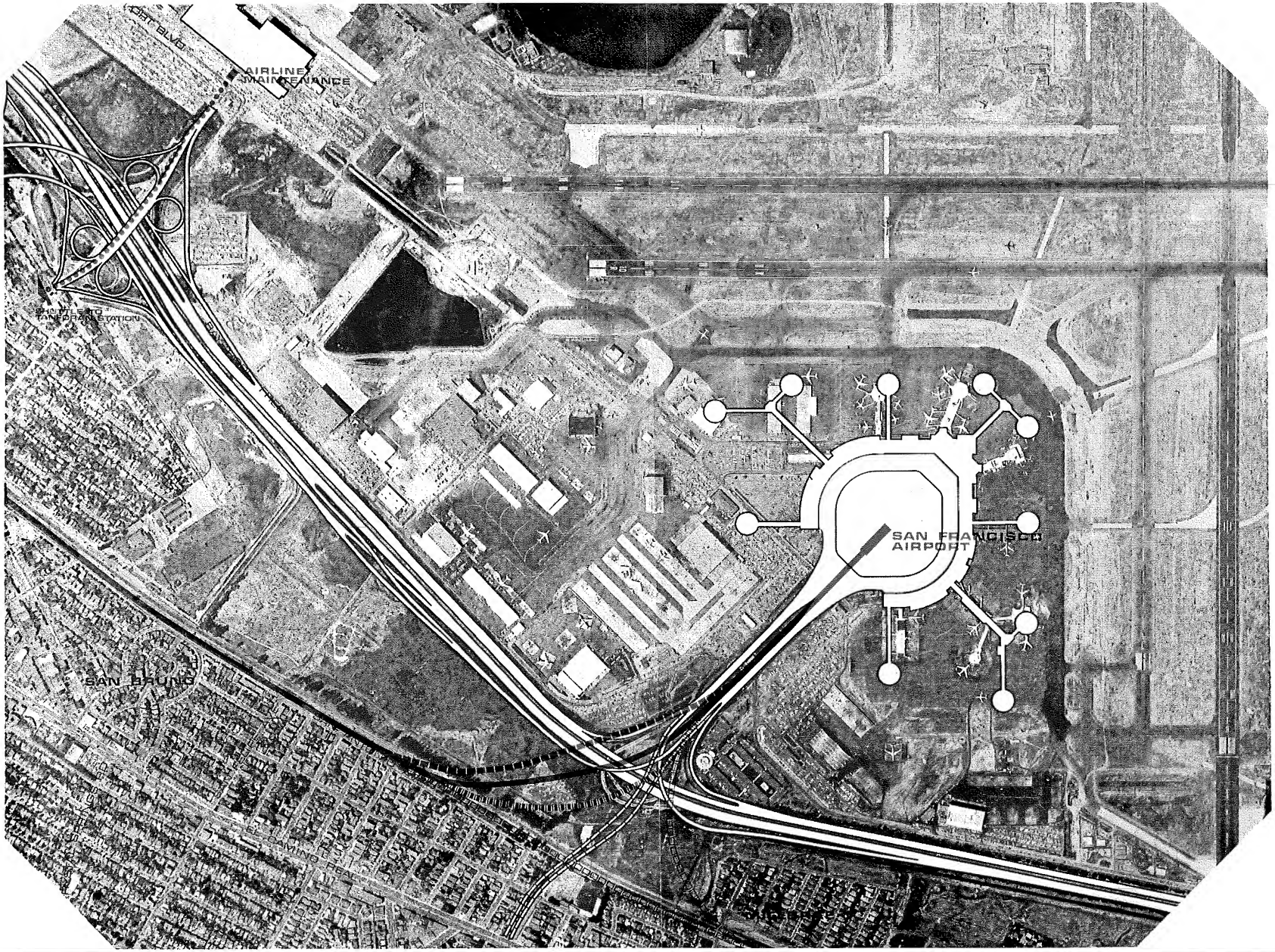
The subway section would also have to be designed to withstand the very substantial aircraft wheel loads of the future. If the cost of the subway to the airport terminal area and the subway station in the terminal area were to follow BART's more expensive subway construction cost experience, it would add $30 to $50 million to the project cost. Should the subway be continued south of the airport, in the future, another $20 to $30 million would be added for the subway section required to clear the terminal structures, apron areas, and taxiways.

The extra cost of the airport subway alignment will increase the financing difficulty as there will be a need to involve more participants. The extra cost not only perpetuates the technology once financed, but limits the development flexibility of the site served. Future airport terminal configurations are somewhat anchored by the subway station location achieved after great expense and difficulty.

The regional significance of these alignments is the greatly increased commitment in the West Bay to the BART-type technology. Most of the benefits of the subway alignments through the airport would not be realized until after an extension south. It is possible that a commitment to build the line south would be a required part of the project.

Alignment C

Alignment C would leave the Market Street Railway right-of-way about a half-mile south of Alignment B and would cross above the Southern Pacific mainline in the vicinity of San Felipe Avenue in San Bruno. It could either be above



LEGEND

- ALTERNATE ELEVATED ALIGNMENTS THROUGH FREEWAY INTERCHANGE COMPLEX
- POSSIBLE FUTURE EXTENSION TO SOUTH
- BART STATION
- POSSIBLE ROUTE OF SHUTTLE SYSTEM

ALTERNATE BART STUB-END ALIGNMENTS TO SFIA

grade or below grade crossing the airport property, Bayshore Freeway, and airport entrance roadway interchange. Several possible alignments for this section of Alignment C are shown in Figure 6.

The possibility of bringing rapid transit below grade to reach the median of the airport entrance roadway was considered. It would add approximately $4 million to the project cost for the north connection and at least as much for a south connection if it were built. Rapid transit would then have to rise above-grade to enter the sixth or seventh level of the Central Space. The appearance of the transition structure was not considered nearly as desirable in the median of the entrance roadway as a relatively straight line structure in a lower cost above-grade alternative.

An elevated crossing of the airport lands offers several possibilities for passing through the multi-level airport-freeway interchange before they merge into one alignment above the median of the entrance roadway.

The new interchange for the airport must be more complex to serve local and regional traffic needs. After studying the complex, it was found that BART structures could penetrate the freeway interchange without impairing operational criteria of either system. This is covered in more detail in the Appendix.

The tightest curve shown on Alignment C will allow speeds of 50 mph, which is the limit of a BART train's acceleration from the nearest projected mainline station to the north. The curve preferred by the project team is shown by a solid line in Figure 6 and in the model photographs.

The suggested alignment for the possible future rapid transit connection to the south is also shown in Figure 6. A corridor approximately 50 feet wide should be preserved along one of these alignments across the airport lands, if it becomes an ultimate objective to so connect SFIA to the south.

Under Alignment C, the BART train would approach the airport terminal on an elevated structure in the median of the entrance roadway. The train would enter the Central Space and stop with an end-of-the-line station. This station would serve air passengers and employees working in the air terminal area. Employees with jobs elsewhere at the airport could be served with a bus shuttle from a station at Tanforan Street in San Bruno as in Alignment B. If an extension of the BART system further south is later determined desirable and financially feasible, the station could function either as a branch line station or a shuttle station.

Implications of Airport Stub-End Service

It appears unlikely that the regional rapid transit system will be funded south of the airport in the 1970's. It is possible that it will never be funded south of the airport. Recognition of this situation increases the importance of serving the airport well with whichever alignment alternative is chosen.

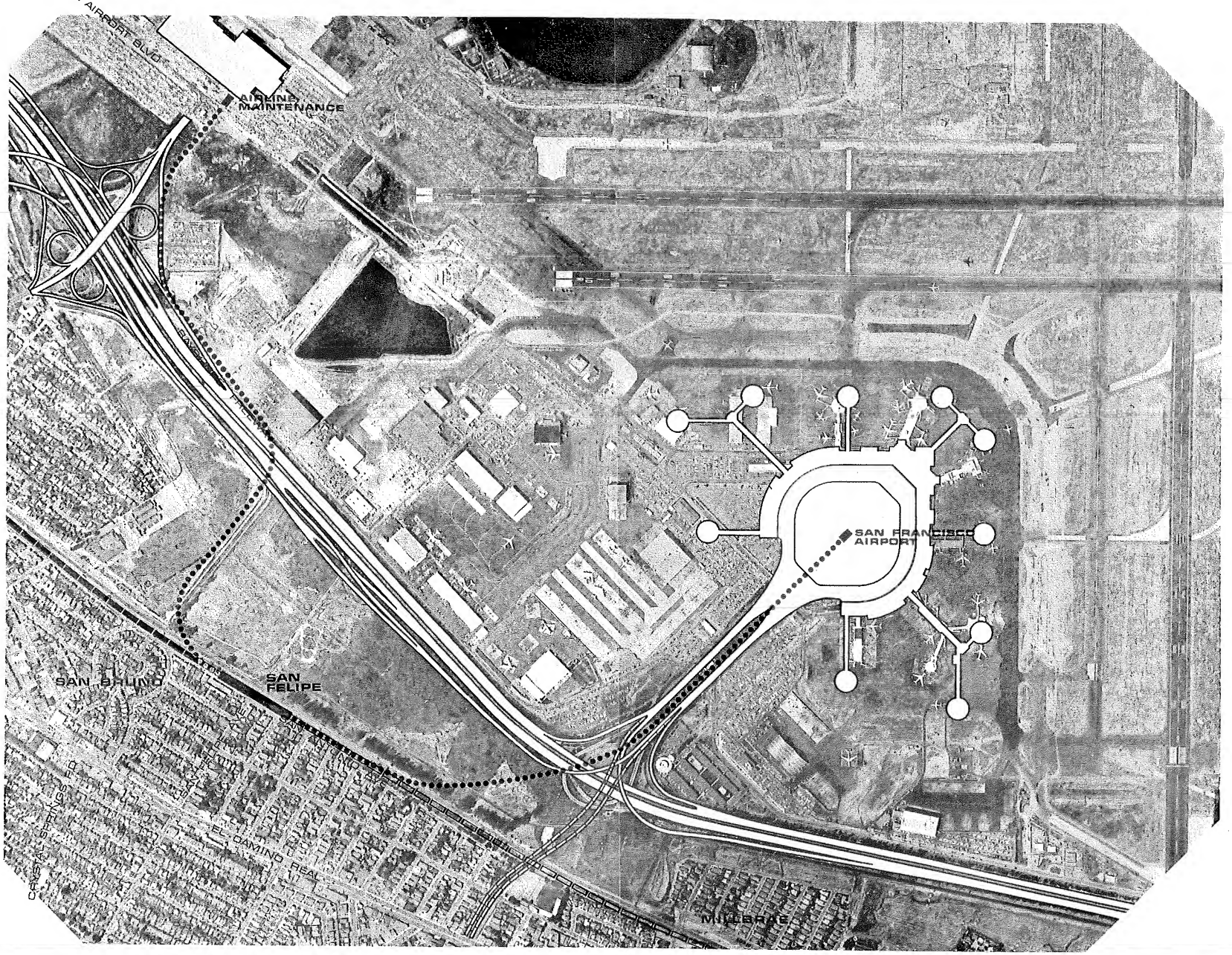
Alignment C, which stub-ends in the Central Space may compromise the north-south service on the ultimate regional rapid transit system, if and when there is an extension of that system south. Yet, one should recognize that the technology for the ultimate system may not have the operating constraints of today. Perhaps it will be possible to fit special airport trains into the stream of traffic even in peak periods by the time of a possible extension south. Lacking even this type of improvement in the technology, the line into the airport could be changed to a shuttle.

In any event, it would seem appropriate to view Alignment C more in the context of its immediate service to the region and the airport. It serves directly 40% of the future job opportunities at the airport and all of the future aircraft positions. This alternative delivers better than 90 percent of the estimated demand for rapid transit to SFIA. Some portion of the remainder, mostly employees, would probably use rapid transit through a shuttle arrangement, either at the San Felipe station or Tanforan station.

Alignment D

The fourth alternative for airport rapid transit service would be along the alignment shown in Figure 7. It would involve stopping the rapid transit line for an end-of-the-line station in the vicinity of San Felipe Avenue rather than the airport terminal area. A structure for some other type of transit hardware would then carry airport passengers on into the airport terminal area. There would be a potential cost savings for the structure depending on the transit hardware. However, the Westinghouse Sky Bus system was estimated to cost about the same as continuing the BART system into the air terminal area. The actual cost saving would depend on whether the shuttle could be an increment to the internal airport people mover system or would be a separate and complete system. Once in the terminal area, the station costs should be less than for BART, especially if a 700-foot platform were required for BART.

A shuttle system would permit all three East Bay lines of BART to serve the airport. With minimum headways, the shuttle could provide nearly continuous service to the Terminal PMS. A shuttle could also serve the maintenance area.



LEGEND

- ALTERNATE BART ALIGNMENT
- POSSIBLE ALIGNMENT FOR SHUTTLE SYSTEM
- BART STATION
- STATION FOR SHUTTLE SYSTEM

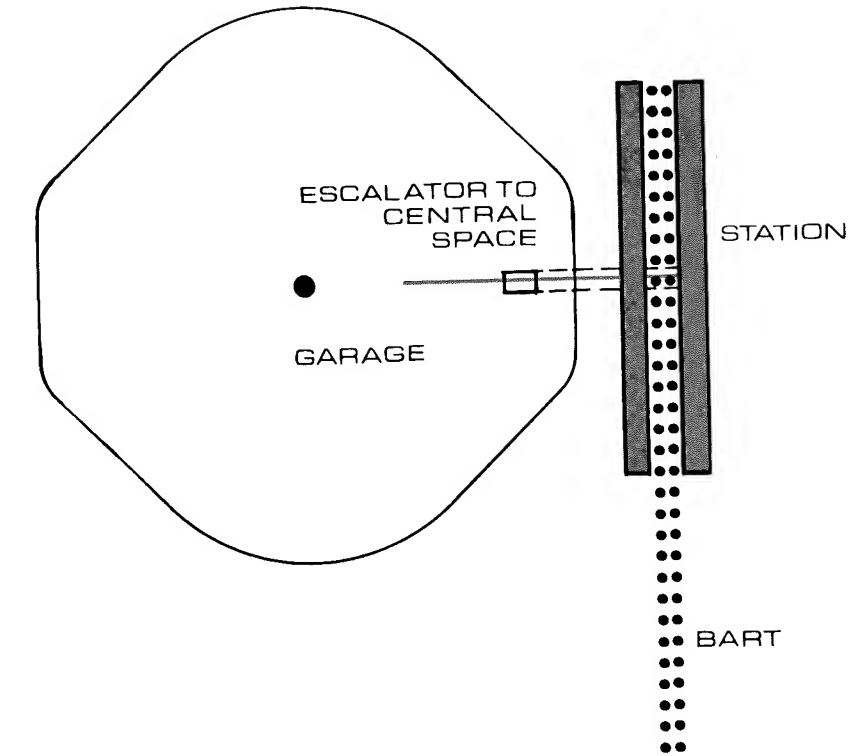
POSSIBLE SHUTTLE SERVICE FROM BART TO SFIA

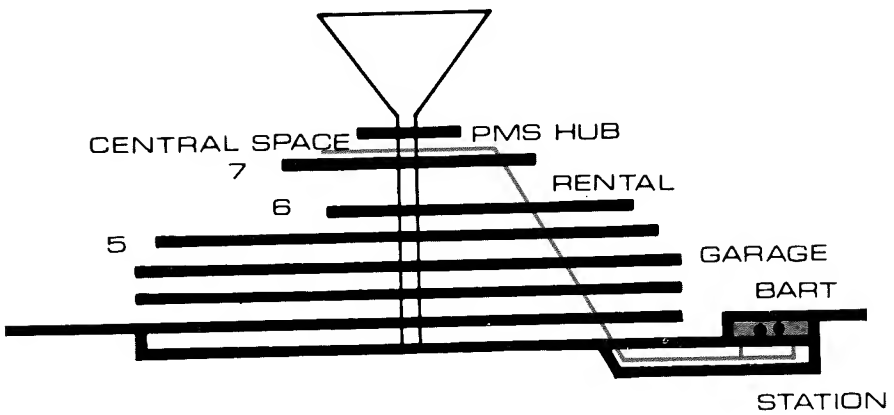
If the Southern Pacific commute service decided to provide a station stop in the vicinity of San Felipe Avenue, there could then be a three-way transfer arrangement between BART, Southern Pacific and the airport shuttle. The transfer from Southern Pacific to a frequent BART service would appear feasible, but there could be considerable difficulty with a transfer in the opposite direction because of the much slower loading times for Southern Pacific and the skip stop service pattern.

Implications of Airport Shuttle Service

Keeping the rapid transit mainline out of the airport terminal area may reduce the convenience of the rapid transit connection to the airport. Much would depend on how completely the more remote rapid transit station could be integrated into the internal airport circulation system for both people and baggage.

A shuttle service increases the risk that a rapid transit extension will not meet the preliminary revenue estimates of the other alternatives. It is not possible to predict the psychological effect on the potential rapid transit user. A remote rapid transit station would be viewed differently than a rapid transit station at the activity center of the airport. Ways to overcome this would have to be studied should this alternative be followed.





SUBWAY BART STATION
CIRCULATION FROM BART TO CENTRAL SPACE SHOWN IN RED

8

STATION CONFIGURATION

This chapter presents the circulation of people and baggage for various station designs in the Central Space. Costs for these stations range from $5 million to $20 million depending on whether the station was elevated or underground. The subway station and sixth/seventh scheme are covered in greater design detail in the appendix.

Subway Station

Alignments A and B would use a side platform subway station to serve the Terminal Area. Located at the western edge of the garage below the entry ramps the BART station could be constructed by a cut and cover operation.

Departing passengers could go directly to baggage drop facilities on the platform and check their baggage. Descending to a lower concourse, they would proceed by continuous, moving walk and escalator up to the seventh level of the Central Space. From here the passengers could take a people mover system vehicle to their destination, or stay in the building and enjoy its restaurant, cocktail lounge, or 150' high observation deck.

The arriving air passenger would come by PMS or pedestrian bridge to the Central Space, drop

down to the BART concourse, claim his bags and then proceed to the station platform above, to await the train.

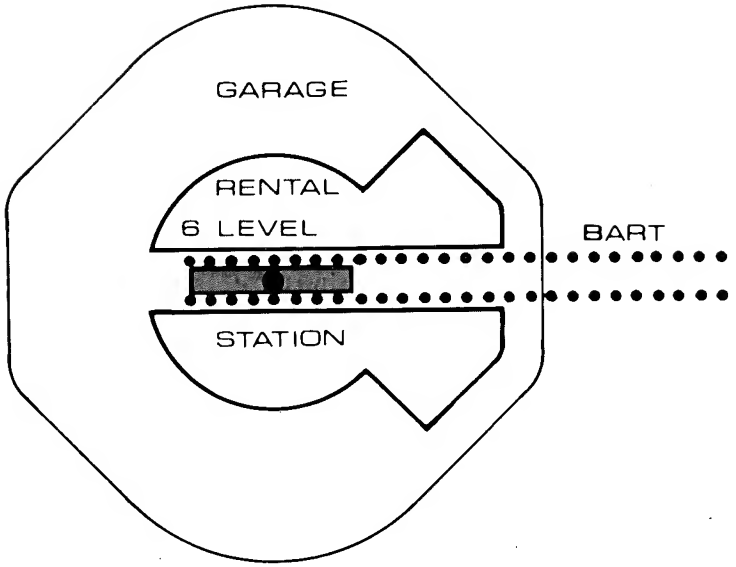
While the travel path is long, it is mechanically assisted to reduce trip time. There is little visual orientation, thus placing heavy emphasis on signing to direct the passenger. Baggage flow is direct as claim and check devices are at or near the sub-basement level where the baggage tunnels are located. The station is 700' long as it is potentially a mainline station where 10-car trains would be stopping.

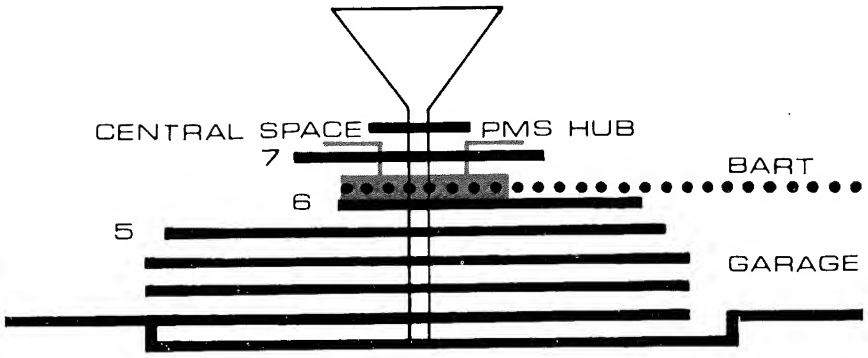
Sixth/Seventh Level Elevated Station

Alignments C and D use central platform elevated stations. The sixth/seventh scheme brings the BART train into a station at the sixth level over the garage, one floor below the seventh level of the Central Space. Virtually no elevation change is required from the interchange at Bayshore Freeway to the station.

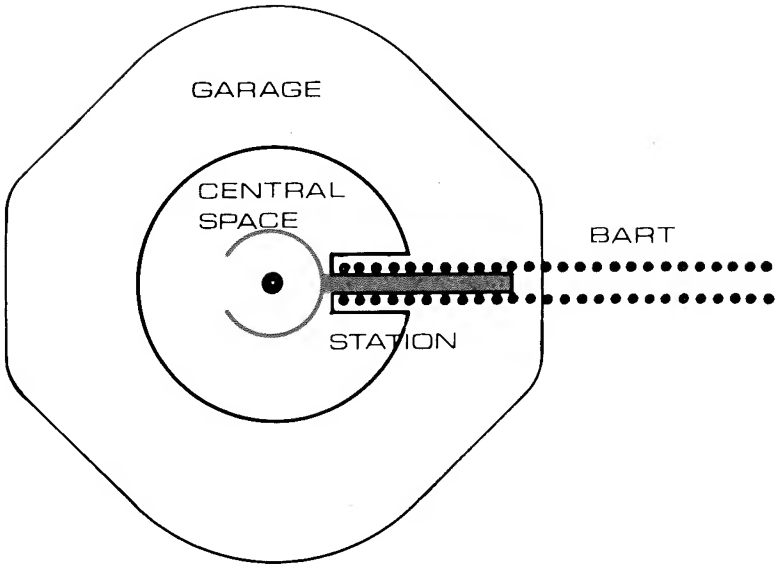
The departing air passenger would go to a baggage-drop on the platform, check his bag and then proceed one level up to the main concourse and PMS boarding areas.

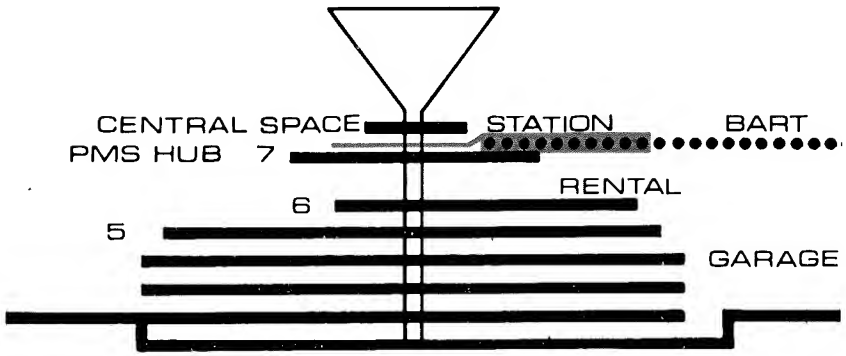
The arriving air passenger would use the PMS or pedestrian bridge to reach the Central Space at the seventh level, then drop down to the sta-





SIXTH/SEVENTH LEVEL BART STATION 9
CIRCULATION FROM BART TO CENTRAL SPACE SHOWN IN RED





SEVENTH LEVEL BART STATION 10

tion below, claim his bag, and catch the next train.

The passenger's travel path is direct, giving him minimum walking distances (approx. 150') and clear visual orientation to his destination.

Baggage flow is adequate as claim and check devices are near planned baggage shafts.

The station shown is 300' long. It is adequate for the 4-car Concord train and is preferred, as the whole platform is within the 450' diameter of the seventh level. A 700' platform can be accommodated functionally and structurally, though less pleasing visually.

This station works as well for a shuttle system, with even shorter walking distances due to the shorter length of the shuttle train.

Seventh Level Elevated Station

This scheme brings BART into a station inside the perimeter and over the structural ring of the new Central Space. This requires a slight change of elevation from the Bayshore interchange to the Station. The station platform is about two feet above the 7th Level.

Departing air passengers would check their baggage on the platform and proceed into the Central Space to wait or to use the available PMS.

Arriving air passengers would walk in, claim their baggage on the platform, and then wait for BART.

The service to the passenger is direct, giving him better orientation to the Central Space - no escalators - but at a price of increased walking distance (420'). Baggage flow is adequate, but has to extend some distance to reach the last claim device.

This scheme is less satisfactory than the sixth/seventh scheme, as nearly 200' of covered platform must extend outside the Central Space. With a 700' train the walking distances and the form are undesirable.

This level is the most suitable for a shuttle system as it would not require a raised platform nor extend outside the Central Space. Walking distances are minimal, and visual orientation is excellent.

PRELIMINARY ANALYSIS OF COSTS AND REVENUES

Summary data have been given earlier in the report regarding estimated rapid transit patronage, revenues and costs. These preliminary estimates were made using rather large geographical units for the analysis of patronage, coarse unit construction costs for the capital cost estimates and coarse unit operating costs for the operating expense estimates. The value of this preliminary analysis lies in determining the potentials of the project. The estimates should be very helpful in making a decision on whether to expend the much larger amount of funds necessary for a more precise determination of costs and revenues. This preliminary work is not intended to shortcut or replace this very important later step that could lead to a funding decision involving many millions of dollars.

The approach used in deriving these preliminary estimates is generally described in the following paragraphs.

Capital Costs

The capital cost and right-of-way estimates developed in the West Bay Rapid Transit Authority study were used whenever possible

in developing the costs for this report. They represent 1968 costs and they have not been inflated to represent future costs.

In sections of the alignment where a variation from West Bay assumptions occurred, rough unit BART construction costs were used. Precise section lengths and unique construction problems were not evaluated. There was no effort to assess utility relocation costs.

The greatest possible variation in the preliminary estimates and final estimates will be for below grade construction in the vicinity of the airport terminal. For this reason, only a wide cost range is given for the alternatives involving subway sections on the airport. These costs are based on BART's most expensive subway construction cost experience. BART's subway cost experience has averaged about $1,600 per foot of single track for tunnelled line sections, but ranges up to $5,400 per foot for the tube approach under the Ferry Building. BART costs even go as low as $600 per foot of single track for cut and cover subway construction. Further consideration of a subway alignment will require expert assistance in several specialties to properly define the best technique for accomplishing the project. It will then be possible to make a more reliable estimate of the subway construction cost.

The scope of this study did not provide for an analysis of the BART incremental equipment requirements and other system modifications to extend service to the Airport. Also, the extra cost of architectural work for rapid transit facilities at the airport is given as a range. Further study is needed to clearly define the extra costs transit adds to the Central Space structure.

Operating Costs

It was assumed that the rapid transit service provided at the airport would be supplied by BART. It is expected that their total operating expenses will be divided by the total car miles operated over the system to obtain a systemwide car mile cost. It has been assumed for the purpose of this report that operating expenses derived in this manner will be 60 cents per car mile.

Within this charge, there may be expenses that will require negotiation, if someone other than BART is to fund the extension. It is possible that there will be some variation in the final operating cost figure as BART refines its requirements to begin operations. Also, all of the car miles estimated to be operated between Daly City and the airport have been charged to the airport service. A portion of this cost may be assigned to intermediate station operations, if intermediate stations are constructed. There is considerable

reserve capacity to meet service demands at intermediate stations in the service assumed for the airport.

Another possible increase in the operating cost estimate could result from a BART requirement to operate 10-car trains to the airport. Obviously, if 10-car trains are operated to and from the airport in peak periods, it would increase the cost of peak period service 2.5 times over the costs assumed in this report.

The operating cost estimate was developed assuming peak period service to the airport would be provided by continuing the 4-car trains operated at 6-minute intervals on the Concord line. It is estimated that this service will provide over twice the capacity needed at the airport in the peak period. It is assumed that the other two East Bay lines would be turned back at Daly City unless passenger demand at an intermediate station beyond Daly City required continuance of one or both of these additional lines.

The service inconvenience to airport users is the transfer requirement for trips from the Hayward and Richmond directions in peak periods. It is estimated that off-peak demand at the airport will require continuing the 2-car trains from either Hayward or Richmond in addition to Concord. As the result, 6-minute service between downtown San Francisco and the airport will be maintained even in the off-peak. People coming from downtown San Francisco will either be offered service to SFIA on every third train in the peak period or two out of three trains in the off-peak. It is estimated that this arrangement will provide direct airport service for about 90 percent of the potential rapid transit users.

The cost of this type of service is approximately $1.3 million per year between Daly City and the airport. The West Bay Rapid Transit Authority study also estimated operating expenses for a similar rapid transit extension, but with more service to intermediate stations.

The estimate of operating expense in the West Bay Rapid Transit study was $1.9 million. No estimate has been made of the additional equipment that may be required.

Patronage and Revenues

The firm of Wilbur Smith & Associates has developed considerable background from which to make rapid transit patronage estimates. It has conducted two extensive origin and destimation surveys of San Francisco International Airport traffic. The first survey was conducted in the fall of 1967 and was sponsored by the Airport. The results were published in December, 1967. A second survey was conducted in August, 1968, and was privately sponsored. The results have not been published.

In addition, an analysis was made of the mode choice for persons traveling to and from the airport based on information in both surveys. A cost network was developed for the various mode choice possibilities.

From this background came an estimate of the diversion that may be expected from the present ground access modes to a future rapid transit extension.

Broad assumptions have been made as to access costs to the rapid transit system. Future traffic is assumed to be distributed around the Bay Area the same as the present traffic, although the growth of Oakland and San Jose airports are likely to change these distributions. It has been assumed that 20 percent of the air passengers will have two or more bags and will not be as likely to use rapid transit. People coming to the airport for other purposes, e. g. flight crew, business, social, are assumed to have the same potential for diversion to rapid transit as air passengers and employees. A very conservative estimate of people accompanying air passengers to guide them, etc. has been made based on the limited experience for transit systems linked to other major airports in the world.

The preliminary estimate of the diversion to rapid transit is for an extension from Daly City to the airport terminal area. No attempt was made to estimate the demand potential of intermediate stations or of an extension of rapid transit south of the airport. The recently completed study for the West Bay Rapid Transit Authority did estimate rapid transit potential at these points for 1975 and 1990 as well as for a shuttle connection to the airport terminal area.

The estimate of rapid transit potential in 1975 at the airport with the shuttle connection is about 3.6 million resident and non-resident air passengers. A conservative analysis completed for this report with the direct airport connection resulted in about the same estimate of air passengers using rapid transit. However, a substantial number of other tripmakers, e. g. employees, flight crew, business people, serve passenger, were also diverted bringing the total rapid transit usage for the airport up to 7.6 million persons per year.

Transforming this estimate of patronage into a revenue estimate requires certain fare policy assumptions. Using the fares suggested for the BART system in the Northern California Demonstration Project could result in about $5 million of added revenue to the BART system. In the analysis of fares for airport traffic, it is apparent that there is considerable margin for an extra charge to air passengers and some margin for other users such as airport employees.

A surcharge for the airport traffic would be a very important source of extra funds to build the rapid transit extension.

It is not without precedent as there is a surcharge planned for the transbay rapid transit service. If everyone was charged an extra 25 cents to and from the airport, it could produce about another $2 million in revenue per year. Such a fare policy would also discourage local use of the airport terminal station.

If certain employers found it worthwhile to encourage rapid transit usage for employees as an alternative to providing more parking, they could purchase BART tickets and resell them at a discount. Perhaps a similar approach would produce an equitable adjustment for the local tax payer already funding BART.

The situation might also be balanced by federal financing of the project to reduce local cost. Financing for the project is well beyond the scope of this report, but it is obviously vital to the ultimate determination of fare policies and cost assignments for the project.

The major conclusion at this point is acknowledgement of the significant revenue potential at SFIA for rapid transit service. The incremental revenues for the regional rapid transit system are estimated to exceed incremental operating expenses by about 5 to 1. With a modest surcharge, the net cash flow that could be used to amortize capital costs is about $5 million per year.

STAGE I SFIA/BART PROJECT

For BART service to SFIA, the approach most timely, least costly, and simplest legally and politically is an eight-mile BART extension from Daly City along available rights-of-way without intermediate stops (Alignment C). Provision for future stations to serve local communities could be made by leaving appropriate tangent sections and structural features on the line.

This approach offers timely action to reduce the pressing problem of traffic congestion at the San Francisco International Airport.

There would be 6-to 15-minute headways during the day on the Concord line. Since the demand at the airport is relatively even during the day (see Figure 3) and actually exceeds the off-peak Concord line capacity, consideration should be given to bringing two of the three East Bay lines to the airport during most of the off-peak period, thus keeping a constant 6-minute service.

The elimination of stations and parking facilities in the first stage of this project eliminates about a third of the costs. The project then comes within the range of financial feasibility to be funded by the initial users of the system. It provides the unusual opportunity in the transit business of funding a major portion of the capital costs of a project with revenue from those directly benefited.

It is estimated that the cost of the extension without stations, using right-of-way largely owned by San Francisco, is approximately $60 million. The major uncertainty remaining involves the provision for intermediate stations, the plans for the station in the air terminal area, and BART incremental equipment requirements. It is estimated that nearly 8 million passengers would use the service annually in the early 1970's when the airport is expected to be handling 24 million air passengers per year. The total annual revenue would be approximately $5 to $7 million, depending on the use of a premium fare for airport passengers. Assuming additional BART operating costs of $1.5 million, this would leave about $3.5 to $5.5 million per year which could pay the local cost of the project in less than 20 years, depending on federal participation and the actual growth of air passenger traffic. The alternative alignments involving subway construction could take considerably longer to repay.

Early amortization of this project has the important advantage of increasing the options for second stage development to include new technology in the north-south peninsula corridor between Marin and San Jose.

In the event new technology did not look attractive at the time a second stage project were to be implemented, the same type of system could be extended on south. At this time, it could also be determined whether to continue mainline trains into the air terminal area and add connections to and from the south or to operate a shuttle on what had been the structure for the BART mainline into the airport in Stage I. Either BART or some other hardware could be used for the shuttle operation. In the event a shuttle option is taken, the existing station in the airport terminal would continue to be serviceable.

Again, it is important to note that the sponsor of the initial extension to the airport may have an investment position to be protected. Ideally the project would have a short economic life so that options for new transit technology would be less constrained.

The long-range development of the project might follow this strategy: A BART extension would be opened in the early 1970's from Daly City non-stop to the San Francisco International Airport. It would be funded from user revenues and the federal capital grant program. It could be paid in full within a 10-20 year period, depending on fare policy, federal assistance, airport growth, and local action to build stations along the line.

Preparation could continue for designing the best rapid transit project to be implemented south of the San Francisco International Airport in

the late 1970's or early 1980's. While it is important to define long-range objectives for the development of the regional rapid transit system, it is equally important not to be frozen to transit hardware prematurely in the enthusiasm to meet these objectives. The research and development effort that is being federally funded may produce some important economic payoffs.

For example, successful development of the tracked air-cushion vehicle might make it possible to construct and operate a Marin-to-San Jose line at much lower cost than is possible using BART technology. It could replace the BART-type hardware link as the best service to SFIA and shift the primary value of the BART extension to providing local service for the communities along the extension. In this case, SFIA would be tied into a new regional rapid transit trunk line built in the Bayshore corridor.

In the event there is no significant breakthrough in new transit technology, SFIA could continue to be served by the present BART-type hardware along the Mission corridor line. The high construction cost associated with this hardware makes it highly unlikely that the entire Marin-to-San Jose route could be included in a second stage regional rapid transit development program.

Consequently, the project would be limited to an extension of the BART-type service from SFIA south. The traffic would then be superimposed on the BART line in the Mission corridor as assumed in the West Bay study. Future usage of the facilities is not estimated to exceed their capacity even in peak periods. After an extension south, the BART structure built into the airport terminal area from the mainline could either be used for branch line traffic or for shuttle traffic.

SUMMARY AND CONCLUSIONS

The San Francisco International Airport is one of the world's busiest commercial airports and the Bay Area's second largest generator of vehicular trips. Only downtown San Francisco produces a greater daily concentration of trips on a unit area basis.

The airport may be the Bay Area's most dynamic activity center because of the continuing growth of air traffic. Major efforts are underway by the California Division of Highways, the City and County of San Francisco, and the airlines to meet the rapidly growing ground access needs at the airport.

BART will soon provide 75 miles of rail rapid transit linking activity centers in San Francisco, Alameda, and Contra Costa Counties. It will terminate just over the border of San Francisco County at Daly City in San Mateo County, eight miles north of the San Francisco International Airport.

The analysis of potential demand for rapid transit service at the airport indicates that there is a sizeable source of extra revenue awaiting an extension of the three-county rapid transit system. It is logical that there would be a considerable increment of revenue in relation to cost for a system that is being built to serve most of the other major activity centers of the Bay Area.

Various possible alignments to the airport were studied. Two basic choices resulted. The first serves the Air Terminal with an underground mainline station and the maintenance facilities with an elevated mainline station. The second serves the Air Terminal with an elevated line that stub-ends in the Central Space of the Terminal Ring and relies on a shuttle system from an upstream mainline station to serve the maintenance facilities. The subway scheme could cost $120 to $140 million and the elevated scheme could cost around $90 million.

The elevated alignments were checked for conflicts with existing or planned service roads, freeway routes and structures, and major airport buildings. From this study, suitable alignments were developed maintaining operational criteria.

Station designs were studied for their impact on the air passenger terminal's, structure, circulation systems, and visual design. Exciting possibilities for both elevated and subway schemes were found.

Unfortunately, the excess of revenues over operating expenses is not estimated to be sufficient to fund the capital costs of the extension. It comes closer to becoming feasible, if the extra cost of constructing stations at other locations along the extension in San Mateo County are eliminated.

The added capacity of rapid transit is of increasing importance to the San Francisco International Airport. Space is limited in the vicinity of the airport. It is bound on one side by the Bayshore Freeway and the other side by the San Francisco Bay. It is estimated that peak demand on the entrance roadway will reach capacity when the airport is handling about 24 million air passengers per year. Storage requirements that can be conveniently met in the airport terminal area are expected to be exceeded at about the same air passenger level. Rapid transit will reduce both demands sufficiently to allow continued airport growth to 30 million air passengers per year and perhaps beyond.

Major policy decisions are ahead primarily for the City and County of San Francisco, BART, and San Mateo County. The first and most important decision concerns the treatment of the rapid transit demand at the San Francisco International Airport. It has already been viewed with interest by proponents of a special purpose rapid transit shuttle to the airport.

Should the policy be established to have as an objective, the extension of BART to SFIA, then these additional policy issues must be dealt with.

INVOLVEMENT OF SAN MATEO COUNTY

San Mateo's involvement could range from whatever is legally required to build the extension in right-of-way generally owned by the City and County of San Francisco, to financial participation to obtain service at intermediate stations.

INVOLVEMENT OF FEDERAL GOVERNMENT

The mass transit capital grant program should provide one source of funds for the extension. The right-of-way owned by the City and County of San Francisco provides one possible source of matching funds.

PROJECT SPONSOR

Good political and technical leadership is fundamental to successful and timely action to implement the project. The same organization must have the ultimate funding responsibility.

RAPID TRANSIT ALIGNMENT

A decision should be made soon as to whether to go for the big package involving an expensive subway through the airport or the lower cost alternative serving the airport terminal area either directly or with a shuttle.

RAPID TRANSIT OPERATIONS

The alternative providing direct rapid transit delivery into the airport parking garage would be best developed as an initial 300-foot platform station that could be ultimately developed to either a 700-foot platform station or reduced to a shuttle station.

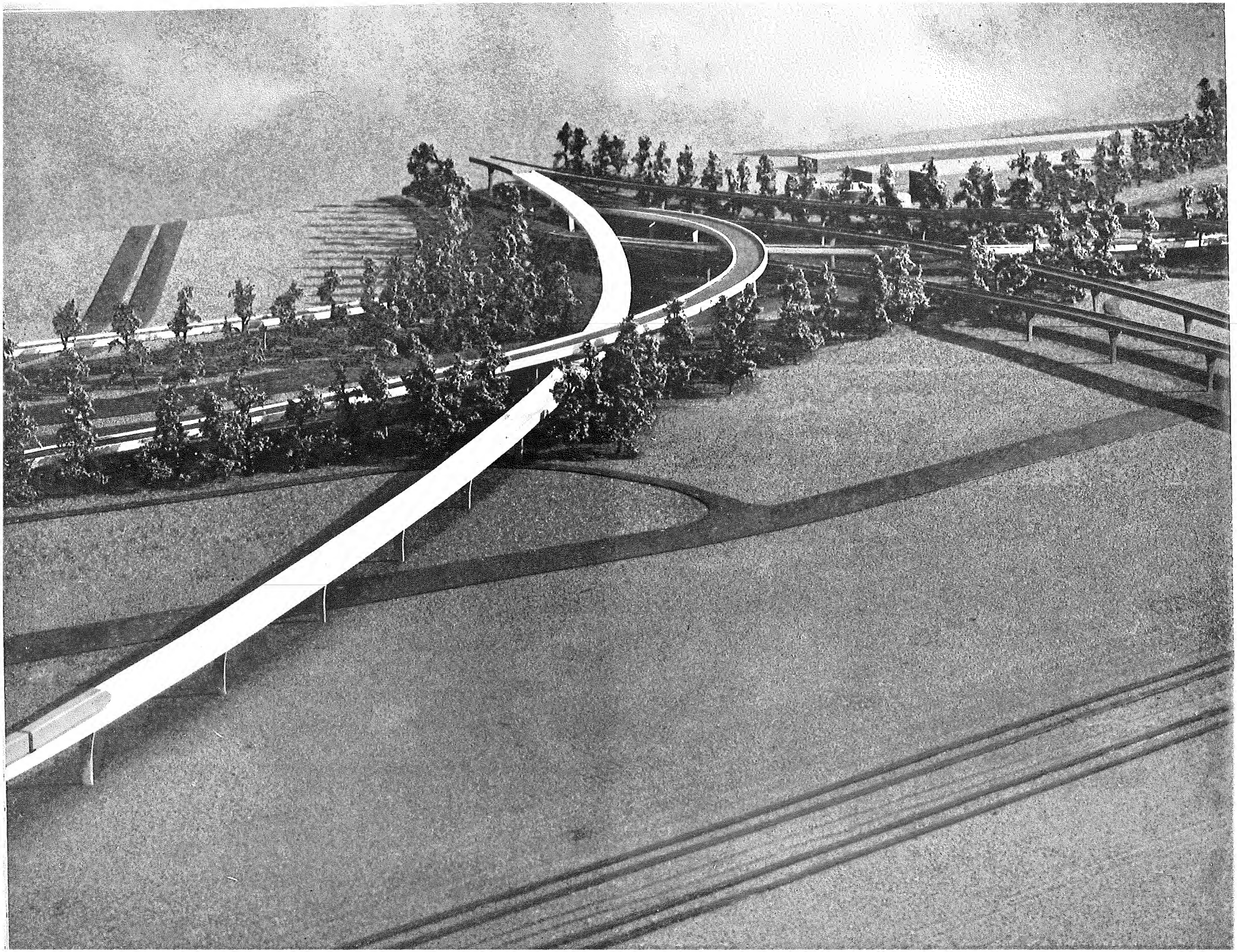
SFIA OPERATIONS, FACILITIES AND LAND

Important decisions are being made now in the airport garage development that will affect the ultimate convenience of a rapid transit station in that location. It is essential to decide on the best rapid transit sta-

tion location and orient design decisions to serve that location whenever possible without undue cost.

The effect of possible transit alignments, and their structures, should be considered as other plans for airport lands are developed. Future arrangements for all competitive transportation modes serving the airport should be carefully reviewed and adjusted as necessary to maintain markets for healthy operations.

APPENDIX



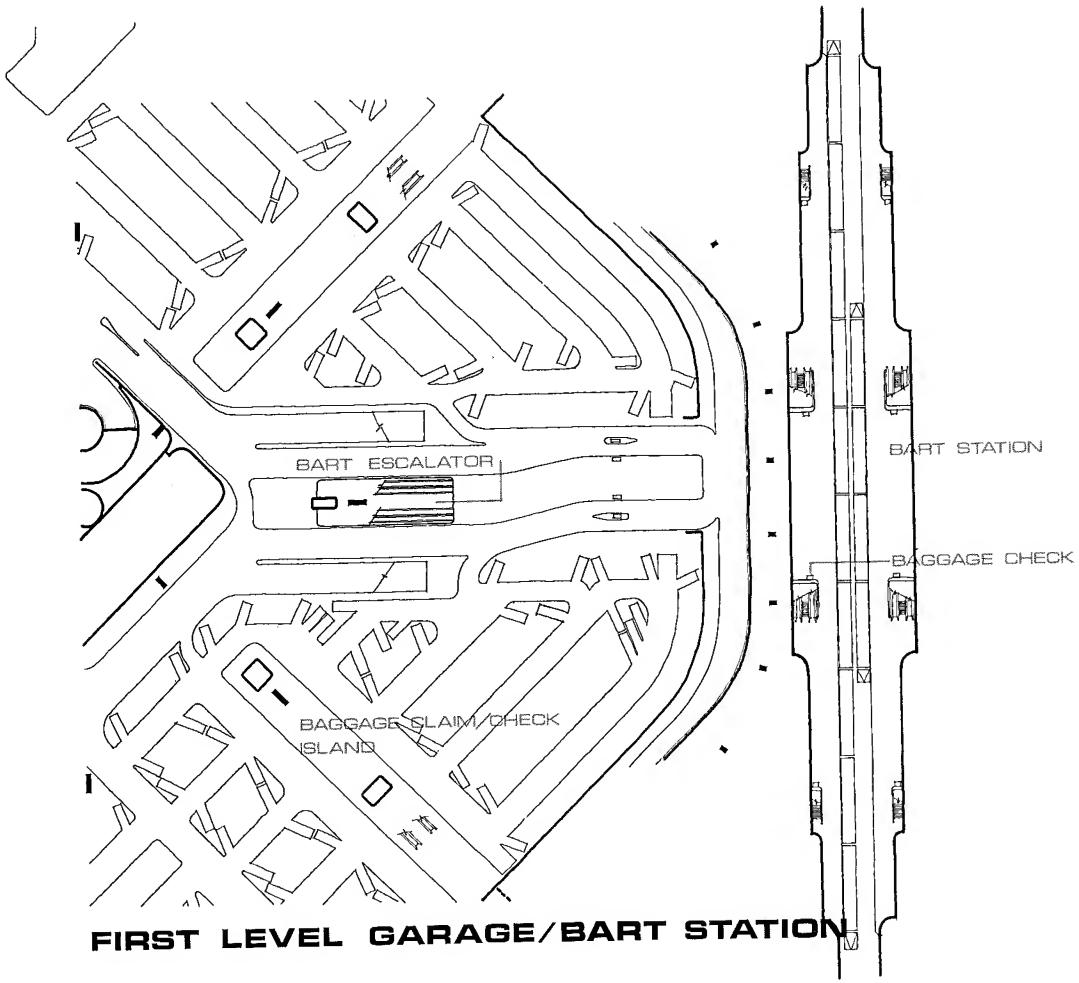
Design Objectives

The ability of a rapid transit right-of-way to provide limited open space and a green belt is a proven benefit. Careful planning and design would maximize this benefit. However, the most critical design areas for a BART extension to the airport are the crossing of the Bayshore Freeway Airport interchange, and the integration of various station concepts into the architectural form and circulation pattern of the Garage and Central Space.

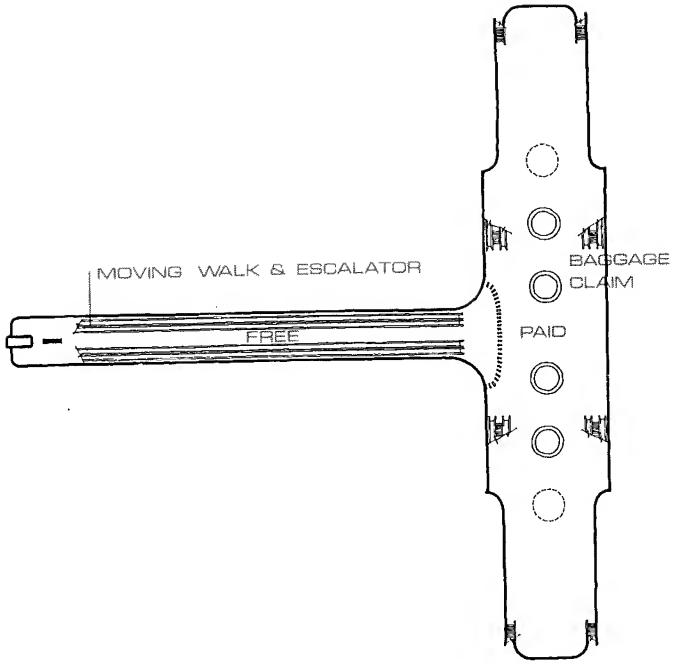
Photographs of the model show the result of considerable study involving operational criteria of rapid transit and conventional highway vehicles, and the planning objectives of the Bay Area Rapid Transit District, the California Division of Highways, and the Airport Department of the San Francisco Public Utilities Commission. Turning radii, spans, column spacings, heights, and clearances between structures were studied to provide an optimum relationship between all the parts of the Interchange Complex.

The design offers an exciting visual experience for BART riders, and for drivers on the interchange or the freeway. Satisfactory speeds, and safety factors are incorporated. Area taken by the interchanges, BART tracks and airport road system was optimized to maintain maximum potential rental parcels on the Airport's land west of the Bayshore Freeway.

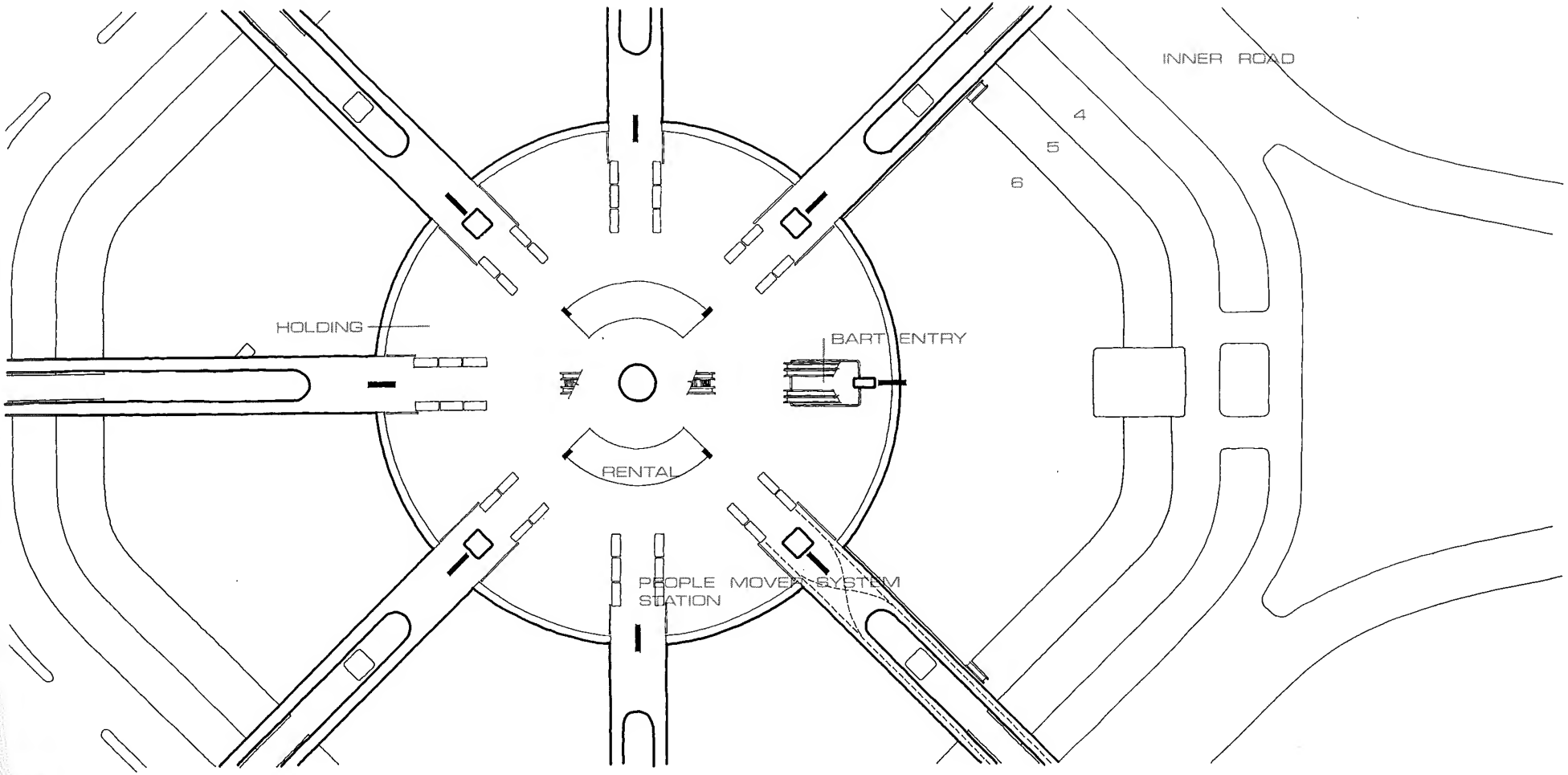
Two station schemes, the subway, and the sixth/seventh, were examined at greater length to assure their structural, mechanical, and architectural feasibility. These two schemes are presented here to indicate the potential of a BART station making a functional and visual contribution to the Airport.



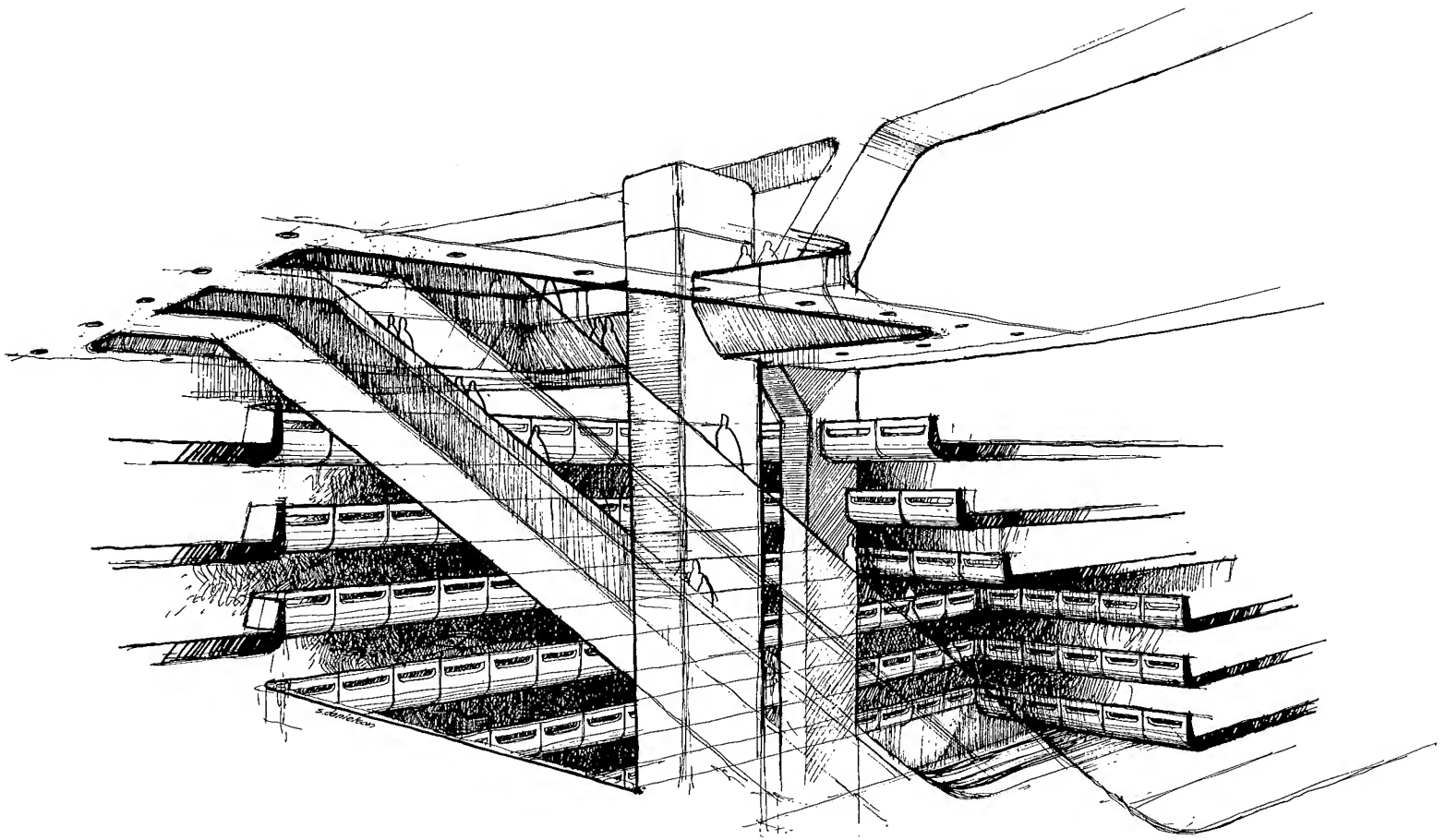
FIRST LEVEL GARAGE/BART STATION



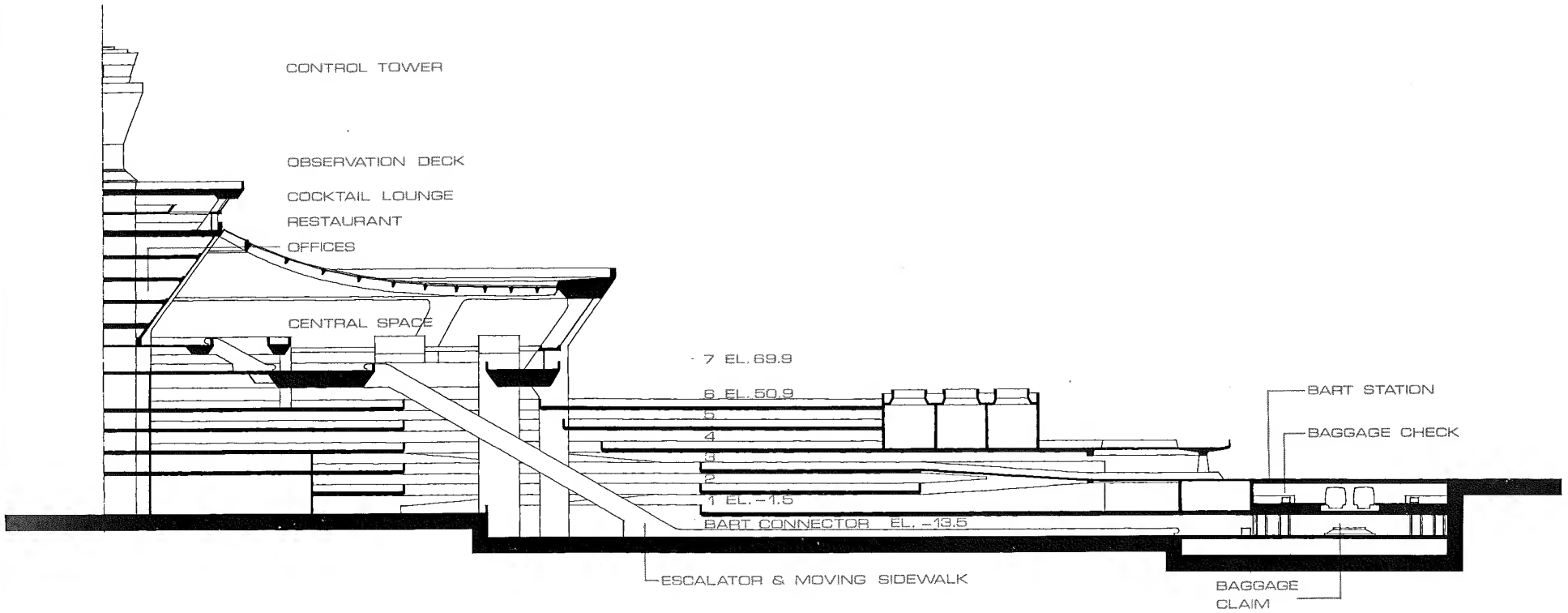
BART CONNECTOR LEVEL



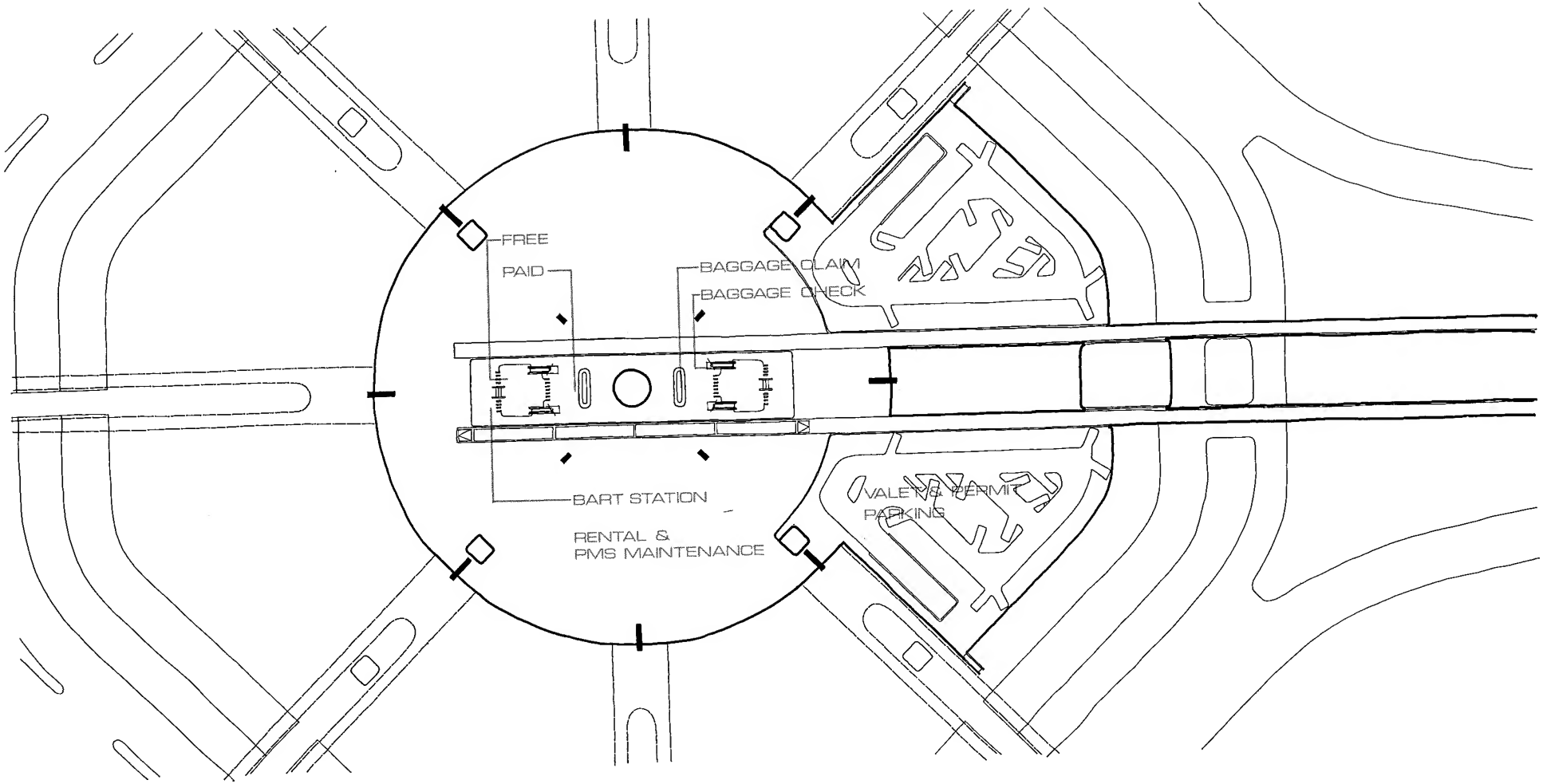
SEVENTH LEVEL CENTRAL SPACE



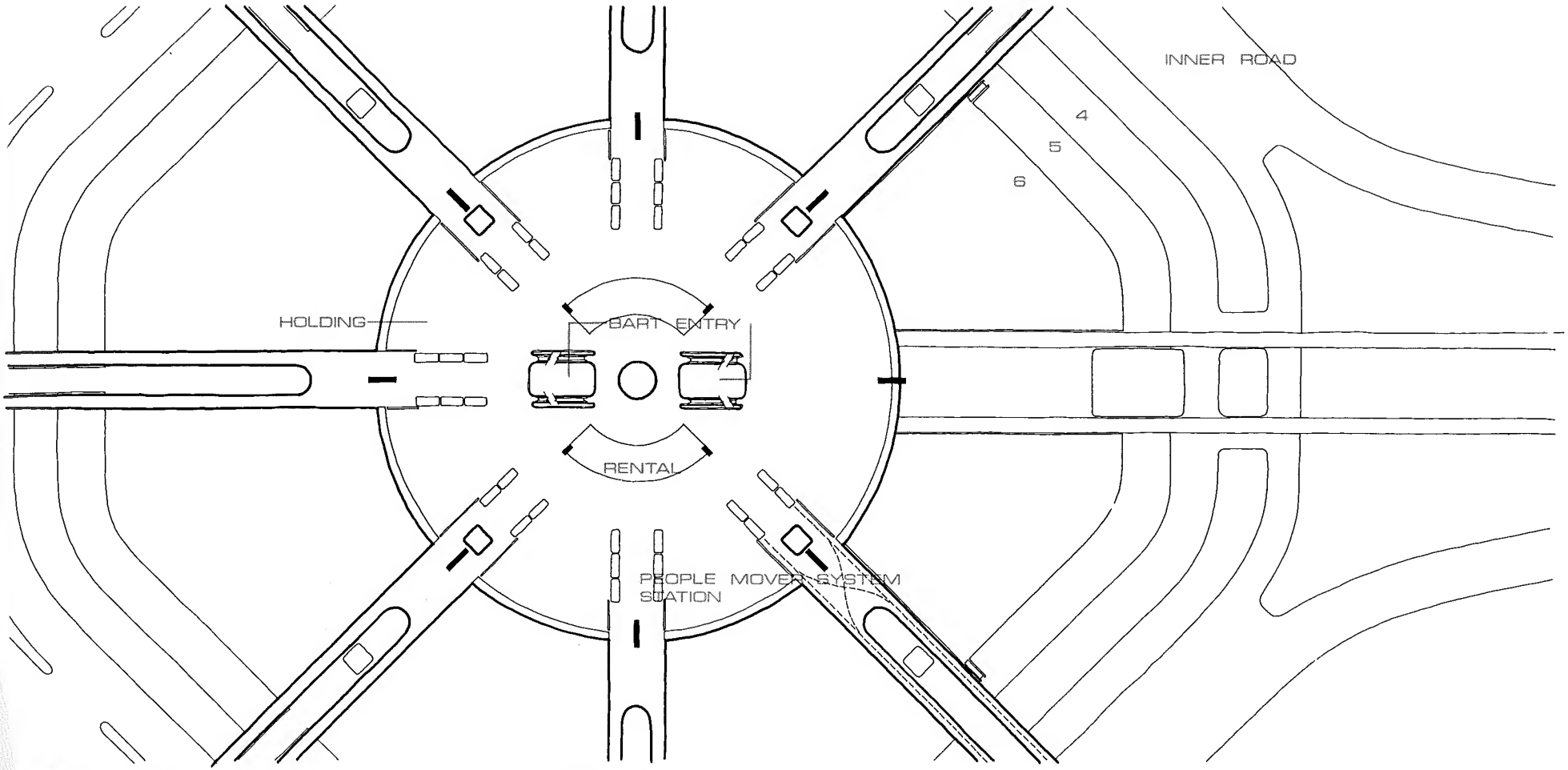
ESCALATOR FROM BART SUBWAY STATION



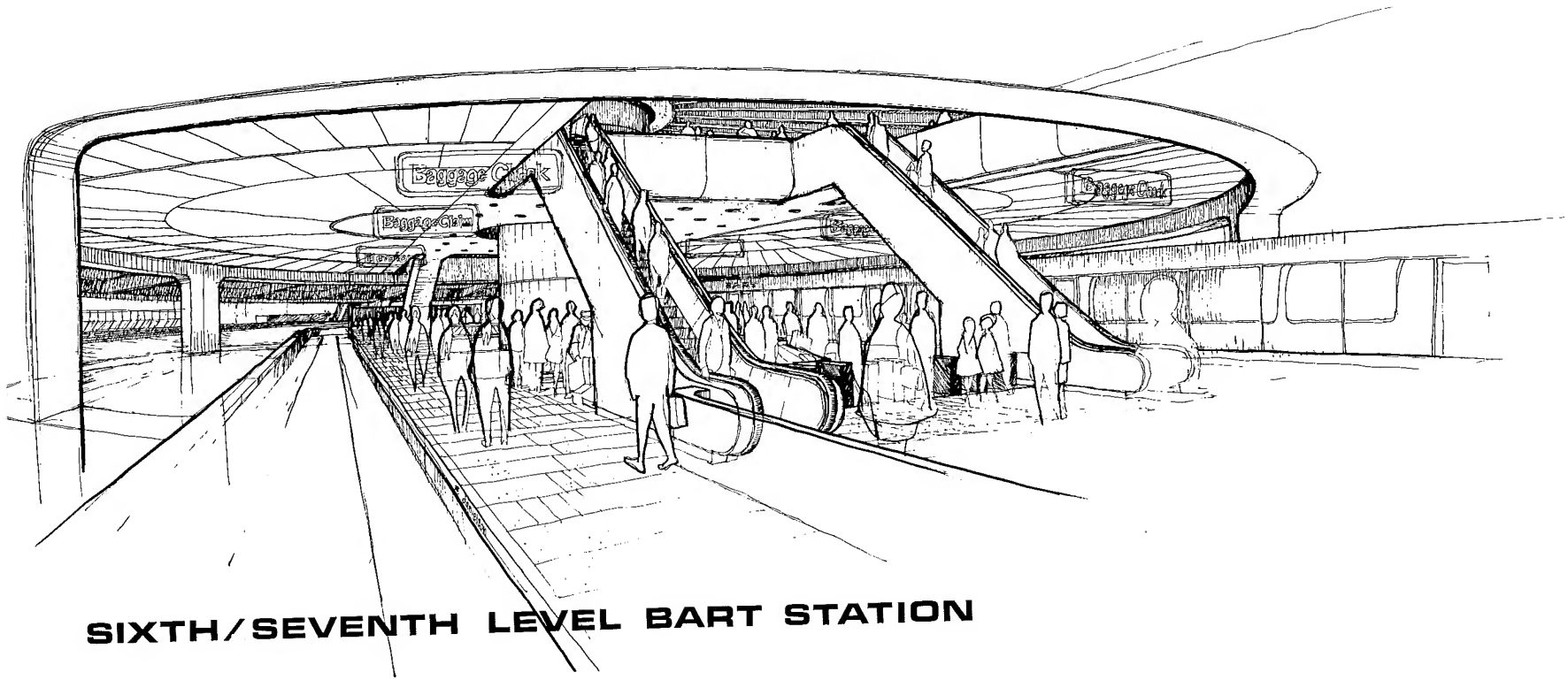
GARAGE/CENTRAL SPACE SECTION



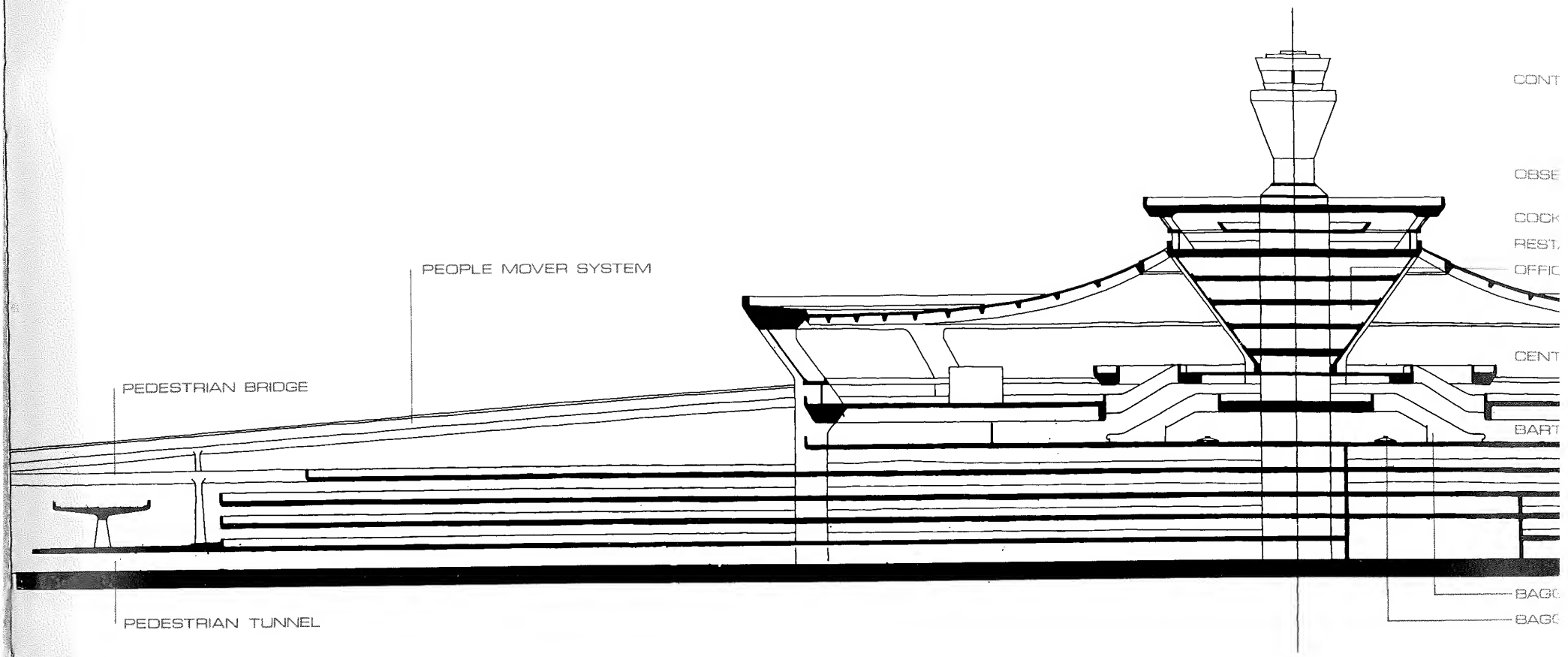
SIXTH LEVEL BART STATION

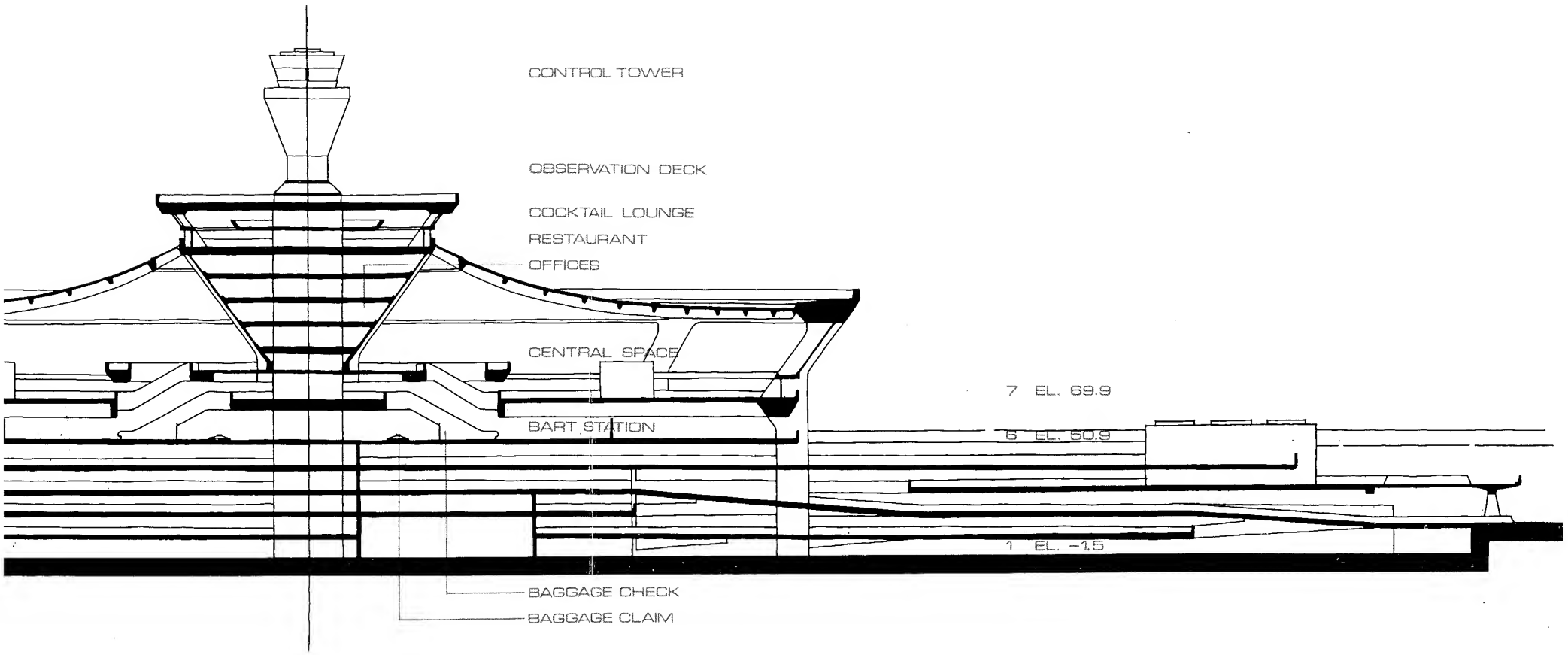


SEVENTH LEVEL CENTRAL SPACE

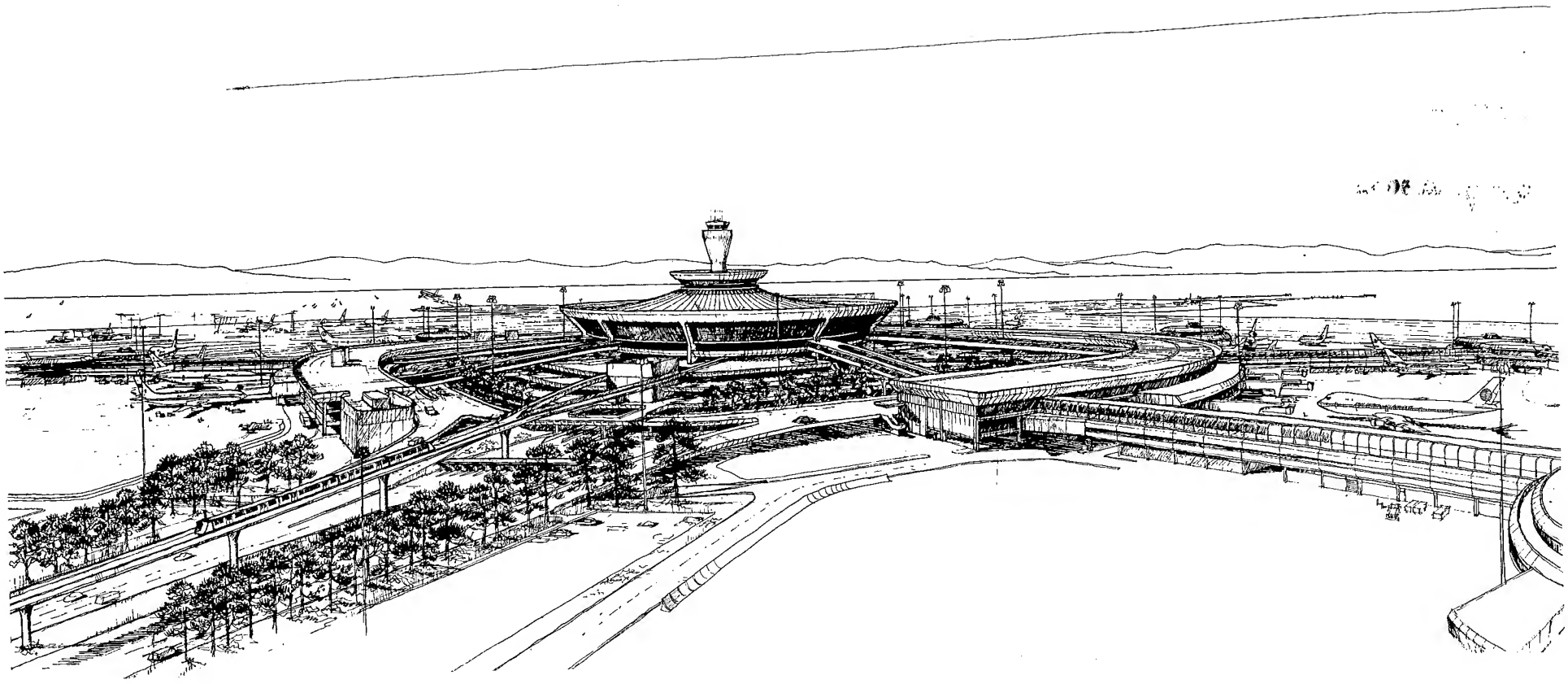


SIXTH/SEVENTH LEVEL BART STATION


PEOPLE MOVER SYSTEM
PEDESTRIAN BRIDGE
PEDESTRIAN TUNNEL
CONT
OBSE
COCK
REST
OFFIC
CENT
BART
BAGG
BAGG



GARAGE CENTRAL SPACE SECTION



VIEW OF TERMINAL COMPLEX
WITH ELEVATED BART SCHEME

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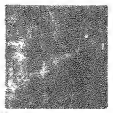

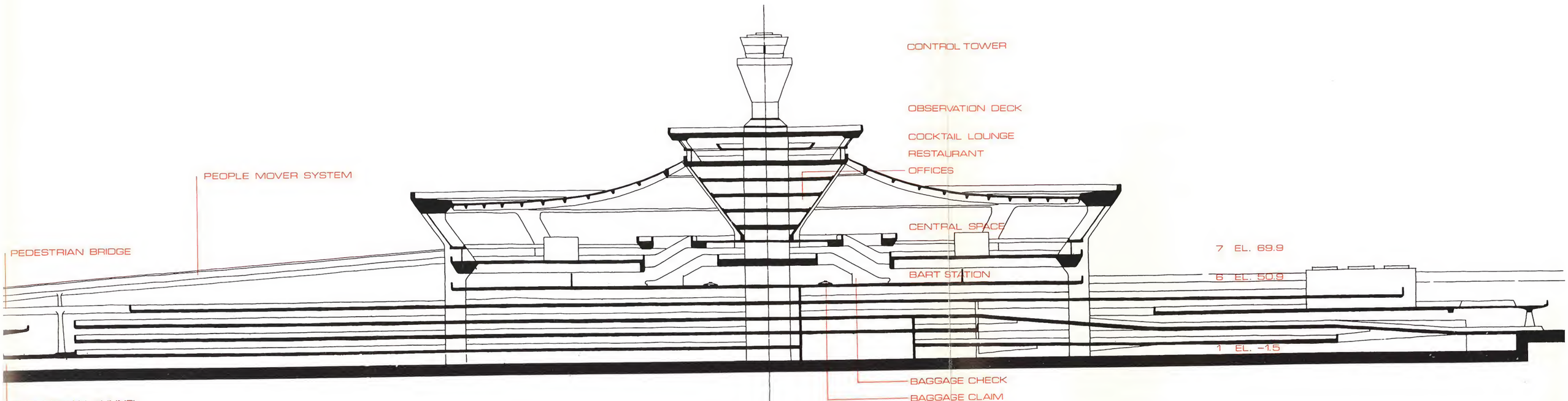

GARAGE CENTRAL SPACE SECTION